# B-PRO 4000

## Bus Protection Relay

## User Manual

**Version 2.0 Rev 5**

# Preface



This manual is part of a complete set of product documentation that includes detailed drawings and operation. Users should evaluate the information in the context of the complete set of product documentation and their particular applications. ERLPhase assumes no liability for any incidental, indirect or consequential damages arising from the use of this documentation.

While all information presented is believed to be reliable and in accordance with accepted engineering practices, ERLPhase makes no warranties as to the completeness of the information.

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# Table of Contents

# Using This Guide

This user manual describes the installation and operation of the B-PRO bus protection relay user interface software. It is intended to support the first time user and clarify the details of the equipment.

The manual uses a number of conventions to denote special information:

| Example | Describes |
|---|---|
| *Start>Settings>Control Panel* | Choose the Control Panel submenu in the Settings submenu on the Start menu. |
| Right-click | Click the right mouse button. |
| *Recordings* | Menu items and tabs are shown in italics. |
| **Service** | User input or keystrokes are shown in bold. |
| Text boxes similar to this one | Relates important notes and information. |
| .. | Indicates more screens. |
| ▶ | Indicates further drop-down menu, click to display list. |
| | Indicates a warning. |

# Acronyms

ASG - Active Setting Group

CCVT - Capacitance Coupled Voltage Transformer

CS - Control Switch

CT - Current Transformer

DCB - Directional Comparison Blocking

DCE - Data Communication Equipment

DIB - Digital Input Board

DIGIO - Digital Input/Output Board

DMDA - Dead Main Dead Aux

DMLA - Dead Main Live Aux

DSP - Digital signal processor

DTE - Data Terminal Equipment

FPCB - Graphics Front Panel Comm Board

FPDB - Graphics Front Panel Display Board

GPS - Global Positioning System

HMI - Human Machine Interface

IED - Intelligent Electronic Device

IP - Internet Protocol (IP) address

IRIG-B - Inter-range instrumentation group time codes

LED - Light-emitting Diode

LHS - Left Hand Side

LMDA - Live Main Dead Aux

LOCB - L-PRO Output Contact Board

LOP - Loss of Potential

MPB - Main Processor Board

MPC - Micro Processor

OOS - Out Of Step

PLC - Programmable Logic Controller

POTT - Permissive Over-reaching Transfer Trip

PUTT - Permissive Under-reaching Transfer Trip

PT - Permissive Trip

RAIB -Relay AC Analog Input Board

RASB -Relay AC Analog Sensor Boards

RHS - Right Hand Side

RPCB - Rear Panel Comm Board

RTOS - Real Time Operating System

RTU - Remote Terminal Unit

SCADA - Supervisory Control And Data Acquisition

SG - Setting Group

SIR ratio - Source Impedance Ratio

TT - Transfer Trip

TUI - Terminal User Interface

UI - User Interface

VI - Virtual Input

WI - Weak Infeed

# Version Compatibility

This chart indicates the versions of Offliner Settings, RecordBase View and the User Manual which are compatible with different versions of B-PRO firmware.

RecordBase View and Offliner Settings are backward compatible with all earlier versions of records and setting files. Use RecordBase View to view records produced by any version of B-PRO firmware and Offliner Settings can create and edit older setting file versions.

Minor releases (designated with a letter suffix - e.g. v1.1a) maintain the same compatibility as their base version. For example. B-PRO firmware v1.1b and Offliner Settings v1.1a would be compatible.

| B-PRO 4000 Firmware/Software Compatibility Guide | | | |
|---|---|---|---|
| **B-PRO Firmware** | **Setting File Version** | **Compatible Offliner Settings** | **ICD File Version** |
| v2.0a | 402 | v2.0 and greater | 1.0 |
| v2.0 | 402 | v2.0 and greater | n/a |
| v1.0b | 401 | v1.0 and greater | n/a |
| v1.0a | 401 | v1.0 and greater | n/a |
| v1.0 | 401 | v1.0 and greater | n/a |

Please contact ERLPhase Customer Service for complete Revision History.

# PC System Requirements and Software

## Installation

### Hardware

The minimum hardware requirements are:

- 1 GHz processor
- 2 GB RAM
- 20 GB available hard disk space
- USB port
- Serial communication port

### Operating System

The following software must be installed and functional prior to installing the applications:

- Microsoft Windows XP Professional Service Pack 3 or
- Microsoft Windows 7 Professional Service Pack 1 32-bit or 64-bit

Relay Control Panel requires Windows XP SP3 (it will not work on earlier versions of Windows).

### Software Installation

The CD-ROM contains software and the User Manual for the B-PRO Bus Protection Relay.

Software is installed directly from the CD-ROM to a Windows PC.

The CD-ROM contains the following:

- B-PRO Offliner Settings: Offliner settings program for the relay
- B-PRO Firmware: Firmware and installation instructions
- B-PRO User Manual: B-PRO manual in PDF format
- B-PRO Function Logic Diagram: diagram in PDF format
- Relay Control Panel: software
- Relay Control Panel User Manual: manual in PDF format
- USB Driver

### To Install Software on the Computer

Insert the CD-ROM in the drive. The CD-ROM should open automatically. If the CD-ROM does not open automatically, go to Windows Explorer and find the CD-ROM (usually on D drive). Open the ERLPhase.exe file to launch the CD-ROM.

To install the software on the computer, click the desired item on the screen. The installation program launches automatically. Installation may take a few minutes to start.

To view the B-PRO User Manual the user must have Adobe Acrobat on the computer. If a copy is needed, download a copy by clicking on Download Adobe Acrobat.

### Anti-virus/Anti-spyware Software

If an anti-virus/anti-spyware software on your local system identifies any of the ERLPhase applications as a “potential threat”, it will be necessary to configure your anti-virus/anti-software to classify it as “safe” for its proper operation. Please consult the appropriate anti-virus/anti-spyware software documentation to determine the relevant procedure.

# 1 Overview

## 1.1 Introduction

The B-PRO 4000 is a microprocessor-based relay providing bus differential protection, integrated breaker failure and overcurrent protection functions, metering, fault and swing oscillography and event logging with one integrated technology.

The relay provides differential protection (low-impedance) for the following types of bus configurations:

- Bus zone, see Figure 1.1: on page 1-2
- Transformer zone.
- 1 bus and one transformer zone, see Figure 1.2: on page 1-3
- 2 bus zone, see Figure 1.3: on page 1-4

Backup feeder protection is provided for all inputs, regardless of which zone is selected, even if an input is not used in a differential zone.

To provide a complete package of protection and control the relay supplies other functions such as:

- ProLogic addresses special protection needs
- Back up overcurrent protection
- Over/under rate of change frequency devices

The Relay Control Panel (RCP) is the Windows graphical user interface software tool provided with all 3000, 4000 series and higher (new generation) ERL relays to communicate, retrieve and manage records, event logs, manage settings (identification, protection, SCADA etc.,), display real time metering values, view, analyze, and export records in COMTRADE format.

In addition to the protection functions the relay provides fault recording (96 samples/cycle) to facilitate analysis of the power system after a disturbance has taken place. The triggers for fault recording are established by programming the output matrix and allowing any internal relay function or any external input to initiate recording.

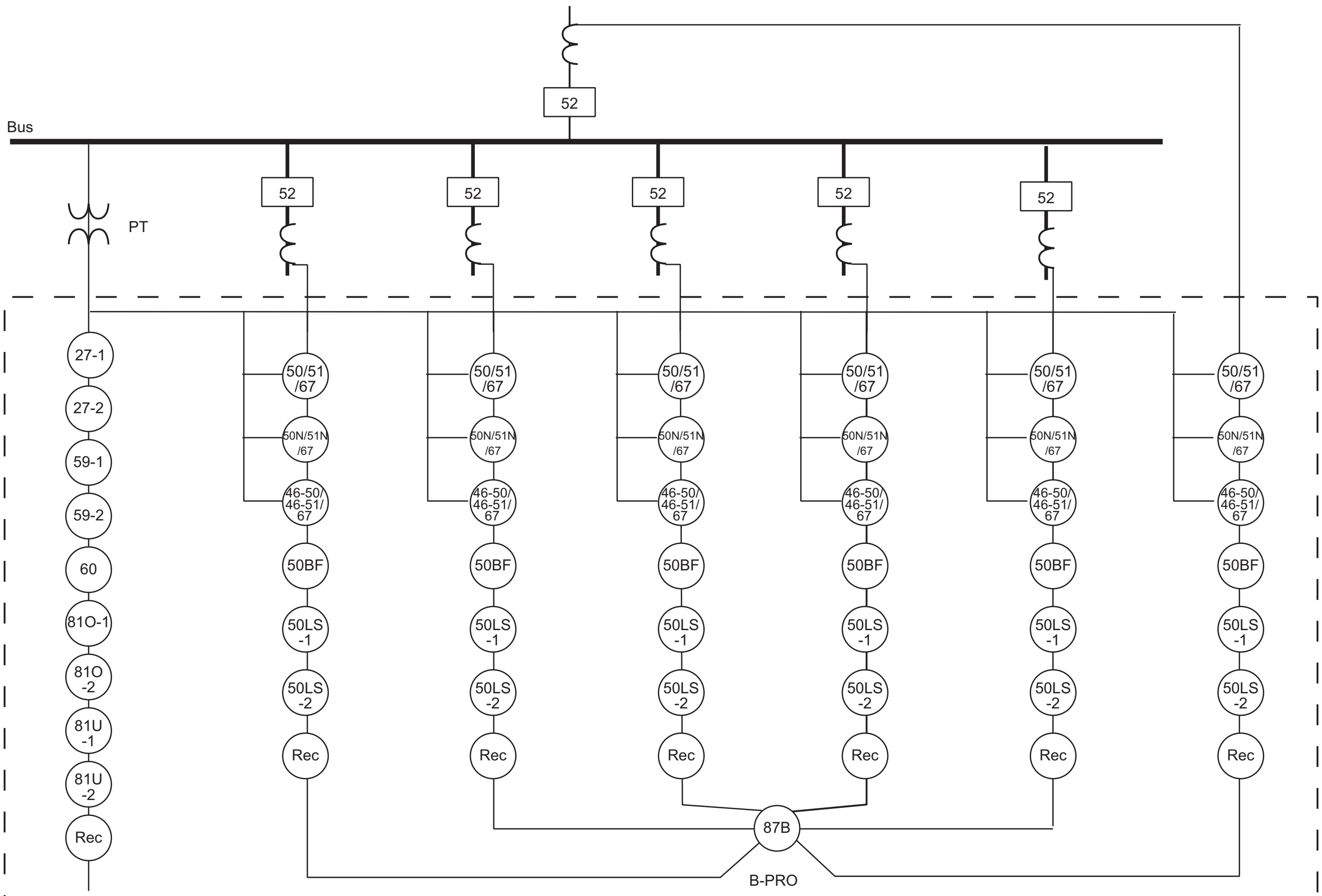



Figure 1.1: B-PRO Function Diagram (1 differential zone)

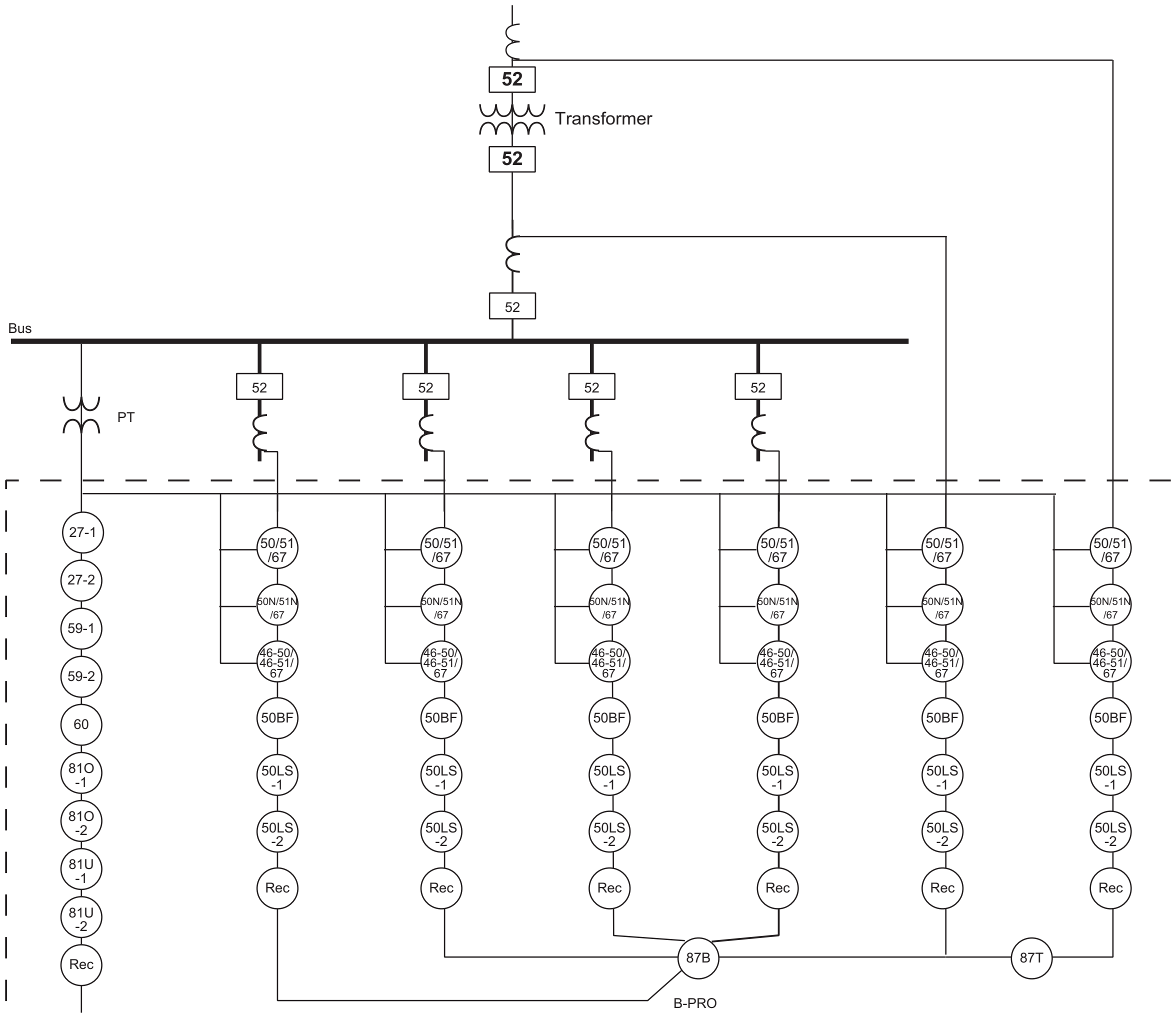



Figure 1.2: B-PRO Function Diagram (2 differential zones, 1 Bus & 1 Transformer)

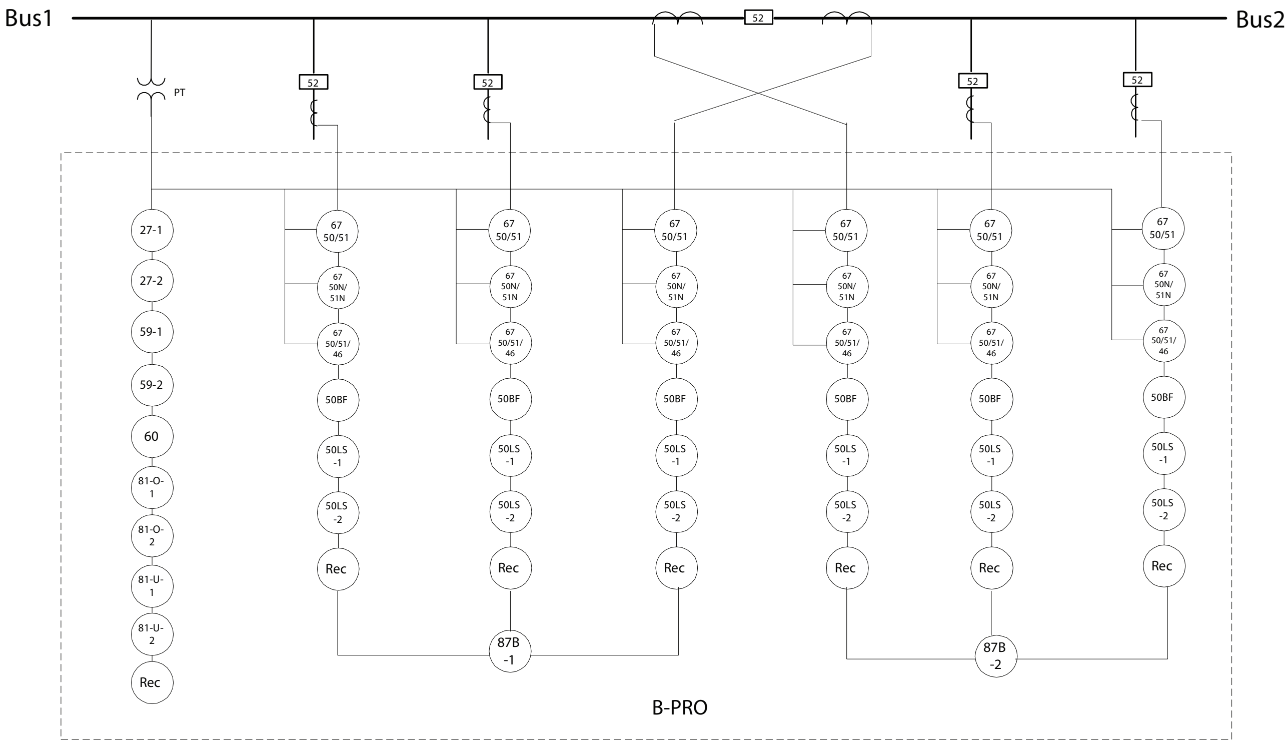
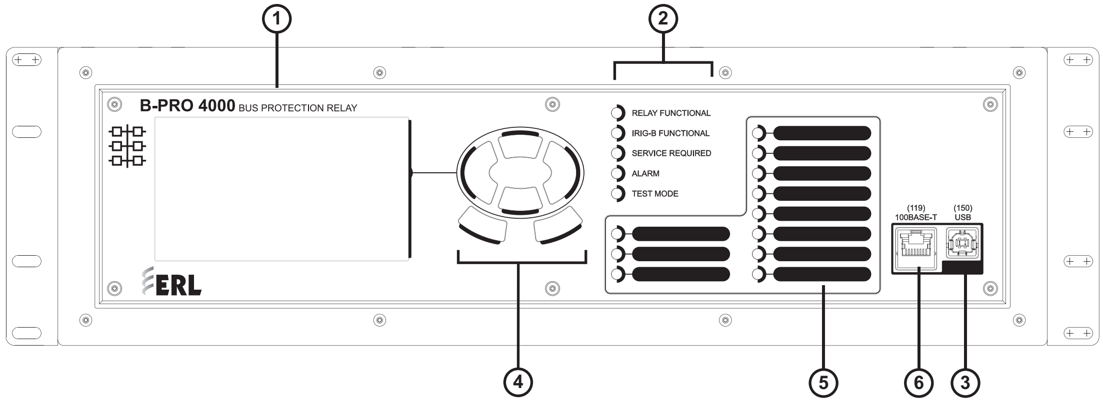



Figure 1.3: B-PRO Function Diagram (2 differential zones: Bus 1 and Bus 2)

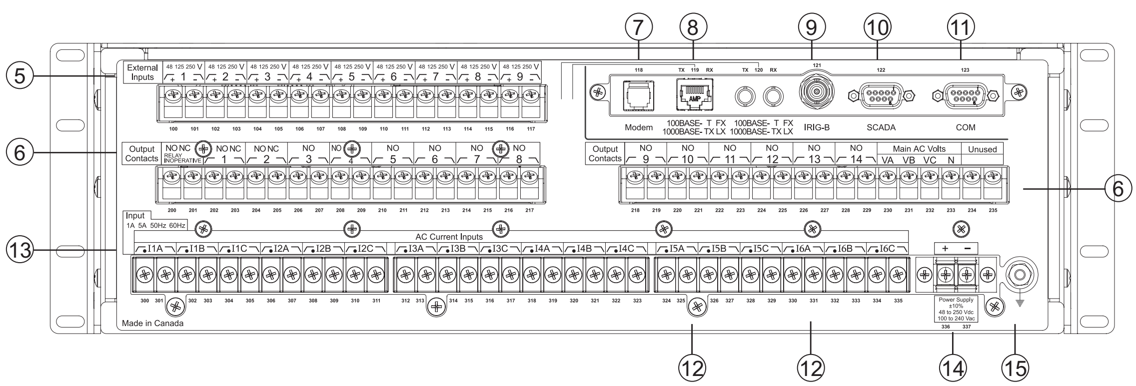
# 1.2 Front View




1. Front display of time, alarms and relay target
2. LEDs indicating status of relay
3. USB Port 150 for maintenance interface
4. Push buttons to manipulate information on display and to clear targets
5. 11 Target LEDs
6. Ethernet Port 119

Figure 1.4: B-PRO Front View

# 1.3 Back View




5. Ports 100-117: 9 External Inputs
6. Ports 200-201: Relay inoperative contact
   Ports 202-229: 14 programmable output contacts
   Ports 234-235: Unused
7. Port 118: Internal modem
8. Port 119-120: 100Base-T or 100Base-FX Ethernet Ports
9. Port 121: External clock, IRIG-B modulated or unmodulated
10. Port 122: SCADA
11. Port 123: Direct/Modem RS-232 Port
12. Ports 324-327, 330-333: AC voltage inputs
13. Ports 300-323: AC current inputs
14. Ports 336-337: Power supply
15. Port with GND symbol: Chassis Ground

Figure 1.5: B-PRO Back View

### AC Current and Voltage Inputs

The relay is provided with terminal blocks for up to 18 ac currents and 3 phase-to-neutral voltages.

Each of the current input circuits has polarity (•) marks.

A complete schematic of current and voltage circuits is shown, for details see "AC Schematic Drawing" in Appendix I and "DC Schematic Drawing" in Appendix J.

### External Inputs

The relay contains 9 programmable external inputs. External dc voltage of either 48 V, 125 V or 250 V nominal are possible depending on the range requested. Selection of specific voltage is factory selectable.

To prevent an external input from picking up on spurious voltage pulses, a software filter is applied to the input signals. The filter ignores logic high voltage levels that occur for less than 2 milliseconds.

### Output Relay Contacts

The relay has 14 output relay contacts. Each contact is programmable and has breaker tripping capability. All output contacts are isolated from each other. The output contacts are closed for a minimum of 100 ms after operation.

### Relay Inoperative Alarm Output

If the relay is in self check program or becomes inoperative, then the Relay Inoperative Alarm output contact closes and all tripping functions are blocked.

## 1.4 Model Options/Ordering

The relay is available as a horizontal mount, for details see "Mechanical Drawings" in Appendix G.

The relay is available with an optional internal modem card. The two rear Ethernet Ports can be ordered as one copper-one optical port or both optical ports. Port 119 on the rear panel is available as either 100BASE-T (RJ-45) or 100BASE-FX (optical ST).

The Current Transformer (CT) inputs are 1 A nominal or 5 A nominal. The external inputs are 48 V, 125 V or 250 V. The system base frequency is either 50 Hz or 60 Hz.

All of the above options must be specified at the time of ordering.

# 2 Setup and Communications

## 2.1 Introduction

This chapter discusses setting up and communicating with the relay including the following:

- Power supply
- Inter-Range Instrumentation Group time codes (IRIG-B) time input
- Communicating with the relay using a network link, a direct serial link and a modem link (internal, external)
- Using Relay Control Panel to access the relay's user interface
- Using HyperTerminal to access the relay's maintenance menu
- Setting the Baud rate
- Accessing the relay's Supervisory Control And Data Acquisition (SCADA) services

## 2.2 Power Supply

A wide range power supply is standard. The nominal operating range is 48 – 250 Vdc, 100 – 240 Vac, +/-10%, 50/60 Hz. To protect against a possible short circuit in the supply use an inline fuse or circuit breaker with a 5 A rating. Ensure that the chassis is grounded for proper operation and safety.

There are no power switches on the relay. When the power supply is connected, the relay starts its initialization process. See "Using the IED (Getting Started)" on page 3-1 for the start up process details.

The use of an external surge protection device is required to pass the surge immunity requirements of IEC/EN 60255-22-5 Criterion A. ERLPhase recommends either of the following for this function:

ERLPhase p/n: 107898

Manufacturer: Phoenix Contact Ltd.

Manufacturer's p/n: 2858357 (PT 2-PE/S 230AC)

or

ERLPhase p/n: 107899

Manufacturer: Dehn Ltd.

Manufacturer's p/n: 953 200 (DR M 2P 255)

One surge protector can be used to protect multiple units as long as the current limit of the surge protection device is not exceeded.

Note that this is a consumable item and not covered by ERLPhase warranty.

### Case Grounding

Ground the relay to the station ground using the case-grounding terminal at the back of the relay, for details see Figure 1.5: B-PRO Back View on page 1-5.

**WARNING!**

Ground the relay to station ground using the case-grounding terminal at the back of the relay, for details see Figure 1.5: B-PRO Back View on page 1-5.

# 2.3 IRIG-B Time Input

The B-PRO is equipped to handle IRIG-B modulated or unmodulated signals and detects either automatically. The IRIG-B time signal is connected to the Port 121 (BNC connector) on the back of the relay. When the IRIG-B signal is healthy and connected to the relay, the IRIG-B Functional LED on the front of the relay will illuminate and the relay's internal clock will be synchronized to this signal.

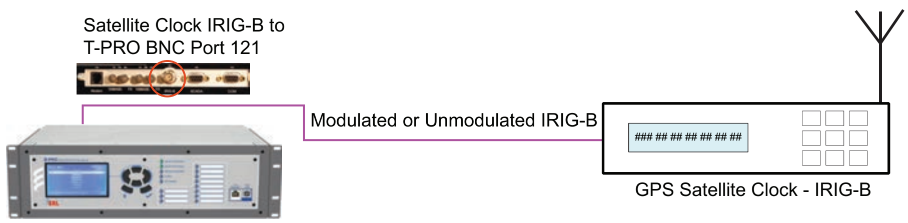



Figure 2.1: B-PRO IRIG-B Clock Connection

In order to set the time in the B-PRO relay, access the setting in Relay Control Panel under the Utilities > Time tab, which is shown in Figure 2.2: on page 2-3. The selection allows the B-PRO to utilize the year extension if it is received in the IRIG-B signal. If the available IRIG-B signal has no year extension, this setting should be disabled.

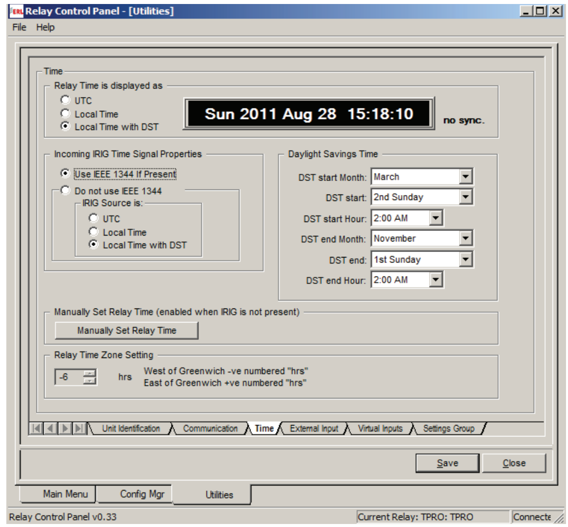



Figure 2.2: Relay Control Panel Date/Time Settings

# 2.4 Communicating with the Relay Intelligent Electronic Device (IED)

Connect to the relay to access its user interface and SCADA services by:

- Front USB 2.0 Service port (Port 150)
- 1 front Ethernet and 1 rear copper or optical Ethernet network links (Port 119)
- Additional copper or optical Ethernet port (Port 120)
- Direct user interface and SCADA serial links (Ports 122 and 123)
- Internal Modem RJ-11 (Port 118)
- IRIG-B Time Synchronization (Port 121)


Figure 2.3: B-PRO Rear Ports

Aside from Maintenance and Update functions which will use a VT100 (e.g., HyperTerminal) connection, all other functions access the B-PRO user interfaces through ERLPhase Relay Control Panel software.

# 2.5 USB Link

The PC must be appropriately configured for USB communication.

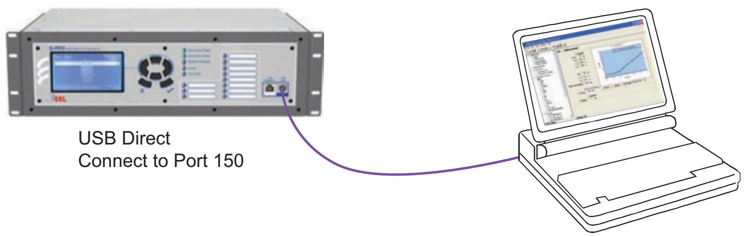



Figure 2.4: Direct USB Link

The B-PRO front USB Port 150 is also known as the Service Port. To create a USB link between the B-PRO and the computer, connect the computer USB port to the Port 150 on the B-PRO front panel using a standard USB peripheral cable.

The USB driver is available in the Support Software downloads section on the

ERLPhase website: http://erlphase.com/support.php?ID=software.

See below under USB Driver a detail explanation on how to install the USB Driver. Ensure the relay port and computer port have the same baud rate and communication parameters.

The relays USB port appears as a serial port to the computer and is fixed at 8 data bits, no parity, 1 stop bit. The B-PRO Port 150 default baud rate is 115,200 and it is recommended to keep this setting. If a different baud rate setting is desired, it can be changed in Relay Control Panel. Select and save the new baud rate setting. You will then have to log back into the B-PRO using the new setting.

When you connect to the B-PRO Service Port, Relay Control Panel will prompt for a Service Access Password. Enter the default password service in lower-case (without the quotes).

### USB Driver Installation

To create an USB link between the relay and the computer, first the USB driver for the ERLPhase 4000 series device needs to be installed, as follows:

Unzip the file (can be obtained from ERL website):

ERLPhase_USB_driver.zip

In this case we assume you unzipped to the desktop.

In Windows XP or Windows 7

Connect a USB port of the PC to Port 150 (USB front) of the BPRO-4000. The BPRO-4000 was already powered on.

In the window

“Welcome to the Found New Hardware Wizard”

“Can Windows connect to Windows Update to search for software?”

Check the option “No, not this time”.

In the window

“This wizard helps you install software for:”

“ERLPhase 4000 Series Device”

“What do you want the wizard to do?”

Check the option “Install from a list or specific location (Advanced)”.

In the window

“Please choose your search and installation options”

“Search for the best driver in these locations”

Uncheck the option “Search removable media (floppy, CD-ROM.)”.

Check the option “Include this location in the search”.

Browse for the following folder:

C:\WINDOWS\tiinst\TUSB3410

In the window

“Hardware Installation”

“The software you are installing for this hardware”

“ERLPhase 4000 Series Device”

“has not passed Windows Logo testing to verify its compatibility with Windows XP” or “Windows can’t verify the publisher”

Hit *Continue Anyway*.

In the window

“Completing the Found New Hardware Wizard”

“The wizard has finished installing the software for”

“ERLPhase 4000 Series Device”

Hit *Finish*.

To verify the installation was successful, and to which comm port is the ERLPhase 4000 Series Device configured, do the following:

In Windows XP go to

*Start > Control Panel->Performance and Maintenance->System >Hardware > Device Manager > Ports*

or (if using Control Panel’s Classic View)

*Start > Control Panel > System > Hardware >Device Manager >Ports*

In Windows 7 ‘small icons’ view, go to

*Start>Control Panel>Device Manager>Ports*

In Windows 7 open HyperTerminal PE; in Windows XP go to

*Start > Control Panel->Performance and Maintenance->System >Hardware > Device Manager > Ports*

or (if using Control Panel's Classic View)

*Start > Control Panel > System > Hardware >Device Manager >Ports*

Look for the port number associated to this device

"ERLPhase 4000 Series Device"

Look for a COM#, where "#" can be 1, 2, 3, etc. Leave the default settings for this port.

It is recommended to restart the PC after the USB driver installation.

The default baud rate for the relay USB Port 150 is 115200, however to double check it login to the relay display and go to:

*Main Menu > System > Relay Comm Setup*

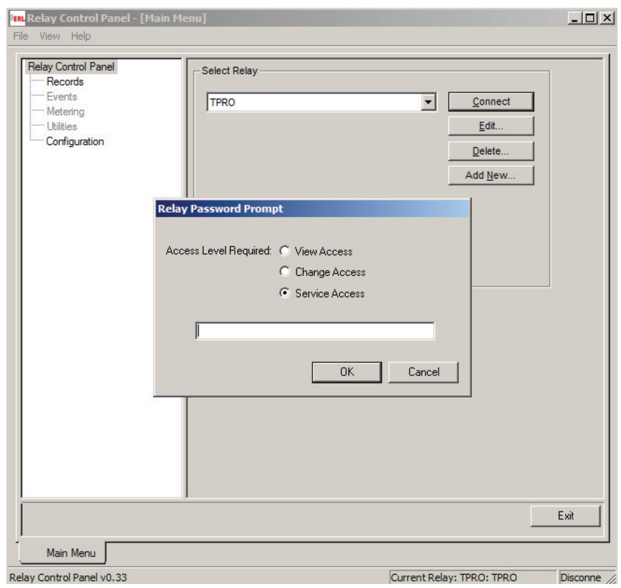



Figure 2.5: Logging into the Service Port 150 in Relay Control Panel

# 2.6 Network Link

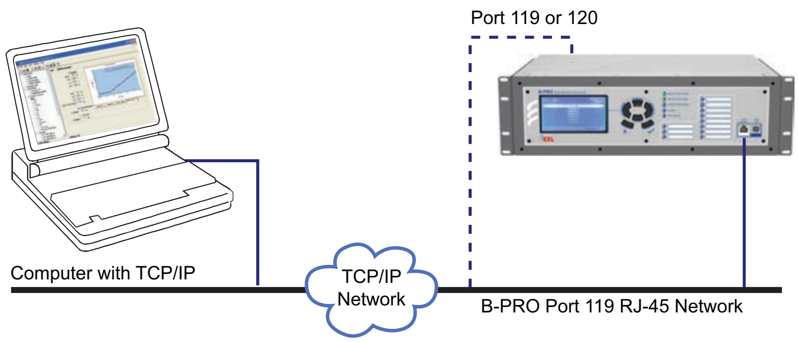



Figure 2.6: Network Link

Access both the relay's user interface and DNP3 SCADA services simultaneously with the Ethernet TCP/IP LAN link through the network ports Port 119 and Port 120. The rear Port 119 and 120 are either 100BASE-T copper interface with an RJ-45 connector or 100BASE-FX optical interface with an ST style connector. Each port is factory configurable as a copper or optical interface. The front Port 119 is 100BASE-T copper interface with an RJ-45 connector.

DNP3 SCADA services can also be accessed over the LAN, for details see "Communication Port Details" on page 2-17.

Connect to the Ethernet LAN using a Cat 5 cable with an RJ-45 connector or 100BASE-FX 1300 nm, multimode optical fiber with an ST style connector.

By default, the Port 119 is assigned with an IP address of 192.168.100.80 Port 120 is assigned with an IP address of 192.168.101.80. If this address is not suitable, it may be modified using the relay's Maintenance Menu. For details see "Network Link" on page 2-7.

# 2.7 Direct Serial Link

To create a serial link between the relay and the computer, connect the computer's serial port and Port 123 on the relay's rear panel provided the port is not configured for modem use. When connected, run Relay Control Panel to establish the communication link.

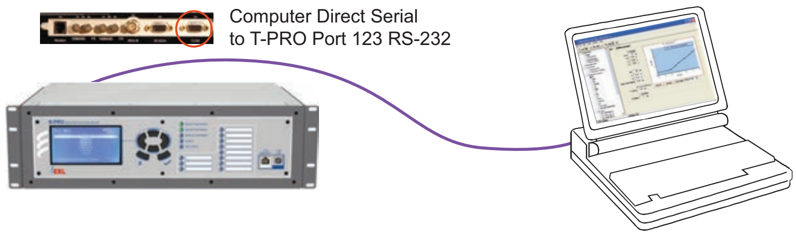



Figure 2.7: Direct Serial Link

The serial ports are configured as EIR RS-232 Data Communications Equipment (DCE) devices with female DB9 connectors. This allows them to be connected directly to a computer serial port with standard straight-through male-to female serial cable. For pin-out details see for details see Table 2.4: Communication Port Details on page 2-17. Rear Port 122 is for SCADA and Port 123 can be used for direct serial access and external modem.

> Ensure the relay port and the PC's port have the same baud rate and communications parameter, see "Maintenance Menu Commands" on page 2-14.

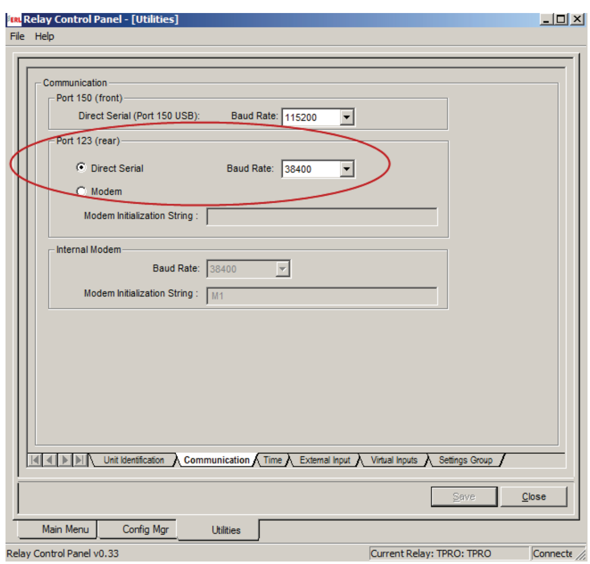



Figure 2.8: Port 123 Direct Serial Configuration in Relay Control Panel

# 2.8 Modem Link

## External Modem

Access the B-PRO's user interface through a telephone link between the relay and the computer by using an external modem.

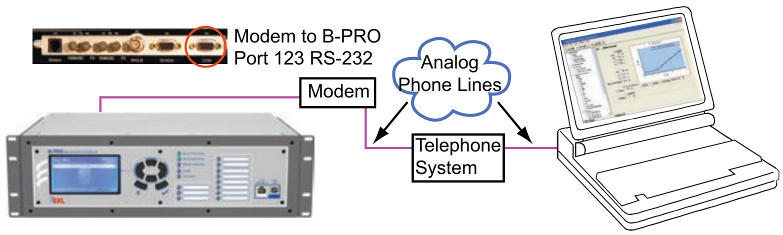



Figure 2.9: External Modem Link

Connect the serial port of the external modem to the Port 123 on the B-PRO rear panel. Both devices are configured as RS-232 DCE devices with female connectors, so the cable between the relay and the modem requires a crossover and a gender change. Alternatively, use the ERLPhase modem port adapter provided with the relay to make Port 123 appear the same as a computer's serial port. A standard modem-to-computer serial cable can then be used to connect the modem to the relay. Pin-out, for details see Table 2.4: Communication Port Details on page 2-17.

Connect the modem to an analog telephone line or switch using a standard RJ-11 connector.

In Relay Control Panel, configure the relay's Port 123 to work with a modem. Go to *Utilities > Communication* and select *Port 123*. Set the *Baud Rate* as high as possible; most modems handle 57,600 bps. The *Modem Initialize String* setting allows the user to set the control codes sent to the modem at the start of each connection session. The external modem factory defaults initialization string is "M0S0=0&B1".

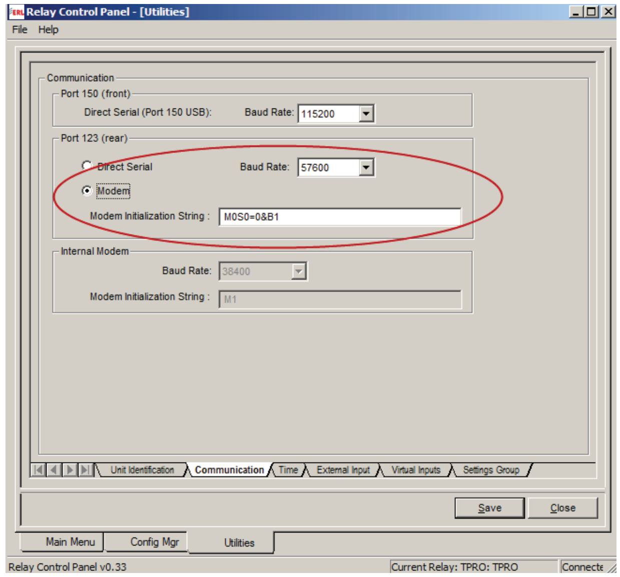



Figure 2.10: Port 123 Settings for External Modem Link in Relay Control Panel

## Internal Modem

Access the B-PRO user interface through a telephone link between the relay and the computer using an optional internal modem. If the modem has been installed, Port 118 on the rear panel is labelled *Internal Modem* and the modem hardware is configured inside the relay.

Connect the relay's Port 118 to an analog telephone line or switch using a standard RJ-11 connector.

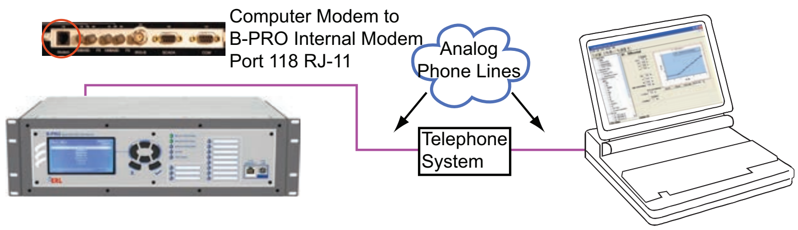



Figure 2.11: Internal Modem Link

The appropriate Port 118 settings are configured at the factory when the internal modem is installed. The factory default initialization string for and Internal modem is "M0S0=0".

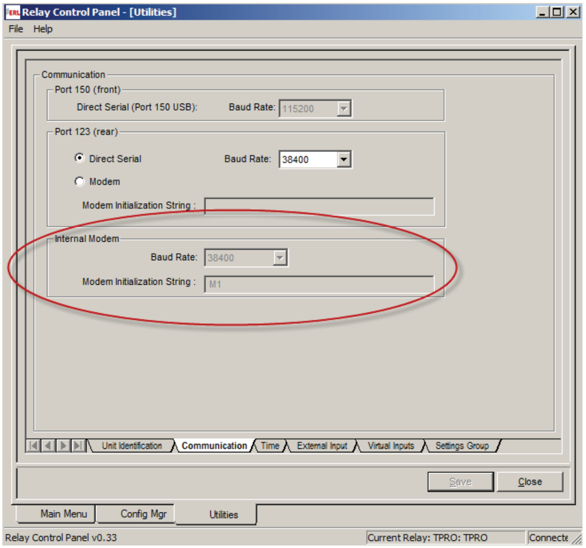



Figure 2.12: B-PRO Internal Modem Settings in Relay Control Panel (circled settings are available when Internal Modem is installed)

# 2.9 Using HyperTerminal to Access the Relay's Maintenance Menu

This section describes how to configure a standard Windows VT-100 terminal program on the computer for use with the B-PRO in order to access the B-PRO maintenance and update functions.

The computer must be connected to the relay via the front USB service port 150.

The relay is accessed using a standard VT-100 terminal style program on the computer, eliminating the need for specialized software. Any terminal program that fully supports VT-100 emulation and provides Z-modem file transfer services can be used. For example, the HyperTerminal program, which is included in Windows XP and is also available separately as HyperTerminal PE, is used here as an example.

Configure the terminal program as described in Table 2.1: on page 2-11 and link it to the appropriate serial port, modem or TCP/IP socket on the computer.

**Table 2.1: Terminal Program Setup**

| | |
|---|---|
| Baud rate | Default fixed baud rate 115,200 N81 (no parity, 8 data bits, 1 stop bit). |
| Data bits | 8 |
| Parity | None |

| Table 2.1: Terminal Program Setup | |
|---|---|
| Stop bits | 1 |
| Flow control | Hardware or Software.<br>Hardware flow control is recommended. The relay automatically supports both on all its serial ports. |
| Function, arrow and control keys | Terminal keys |
| Emulation | VT100 |
| Font | Use a font that supports line drawing (e.g. Terminal or MS Line Draw). If the menu appears outlined in odd characters, the font selected is not supporting line drawing characters. |

To configure HyperTerminal follow this instructions:

In Windows 7 open HyperTerminal PE; in Windows XP go to

*Start* > *All Programs* > *Accessories* > *Communications* > *HyperTerminal*

If "Default Telnet Program?" windows pops up,

Check "Don't ask me this question again"

Hit *No*.

First time use of HyperTerminal will ask for "Location Information".

Fill with appropriate information, e.g.:

"What country/region are you in now"

Choose "Canada"

"What area code (or city code) are you are in now?"

Enter "306"

"If you need to specify a carrier code, what is it?"

Enter "", i.e. leave blank

"If you dial a number to access an outside line, what is it?"

Enter "".

"The phone system at this location uses:"

Choose "Tone dialing".

Hit *OK*.

First time use of HyperTerminal will show "Phone and Modem Options".

Hit *Cancel*.

HyperTerminal will show initially "Connection Description".

Enter a name for the relay, e.g: "BPRO4000".

Hit *OK*.

In the window "Connect To"

"Connect using"

Choose "COM#", where "#" was obtained previously in Section 2.5 USB Link, after installing the USB driver.

Let's assume in this case it is COM3.

In the window "COM3 Properties" choose:

"115200"

"8"

"None"

"1"

"Hardware"

Hit *Apply* then hit *OK*

At this time the connection should already be established.

Hit *Enter* in the terminal window.

Login as **maintenance** in lower case.

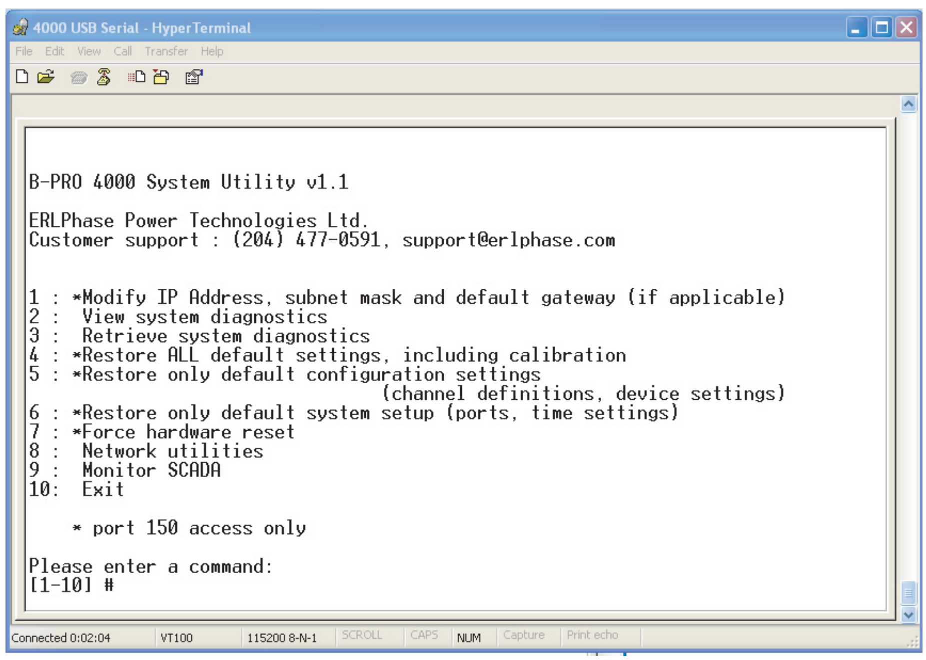



Figure 2.13: Maintenance Menu

## Maintenance Menu Commands

Commands 1, 4, 5, 6 and 7 are Port 150 access only.

| Table 2.2: Maintenance Menu Commands | |
|---|---|
| Modify IP address | Modifies the LAN IP addresses, network mask, default gateway and IEC61850 network port assignment. |
| View system diagnostic | Displays the internal status log. |
| Retrieve system diagnostics | Automatically packages up the internal status log plus setting and setup information and downloads it in compressed form to the computer. This file can then be sent to our customer support to help diagnose a problem. |
| Restore settings (commands 4, 5 and 6) | Use these commands to force the system back to default values, if a problem is suspected due to the unit's settings, calibration and/or setup parameters. |
| Force hardware reset | Manually initiates a hardware reset. Note that the communication link is immediately lost and cannot be reestablished until the unit completes its start-up. |
| Network utilities | Enters network utilities sub-menu, for details see Table 2.3: Network Utilities on page 2-14. |
| Monitor SCADA | Shows real time display of SCADA data. |
| Modify IEC61850 IED name | Modifies IED name of the IEC61850 device. This name has to match the name in the CID file and the name change via this command shall be coordinated with the new CID file download. |

| Table 2.3: Network Utilities | |
|---|---|
| View protocol statistics | View IP, TCP and UDP statistics. |
| View active socket states | View current states of active sockets. |
| View routing tables | View routing tables. |
| Ping | Check network connection to given point. |
| Exit network utilities | Exit network utilities menu and return to Maintenance Menu Commands. |

# 2.10 Firmware Update

The relay has an "update" login that can be accessed by a connection through a VT100 terminal emulator (such as HyperTerminal). This login is available only from Port 150.

1. Use the terminal program to connect to USB service Port 150.
2. Select *Enter:* the terminal responds with a login prompt.
3. Login as **update** (without the quotes) in lower case.
4. The firmware update is used to update the relay's internal software with the latest maintenance or enhancement releases. Please see the B-PRO Firmware Update Procedure documentation that comes with the firmware update file and instructions.

# 2.11 Setting the Baud Rate

The baud rate is available on the LCD screen from the top level menu selecting *System* then *Relay Comm Setup*.

## Direct Serial Link

For a direct serial connection, both the relay and the computer must be set to the same baud rate.

To change the baud rate of a relay serial port:

1. The user needs to log into the relay as **Change** (any port) or **Service** (USB port only) using RCP.
2. Then choose *Utilities>Communication* tab.

## Modem Link

Unlike a direct serial link, the baud rates for a modem link do not have to be the same on the computer and on the relay. The modems automatically negotiate an optimal baud rate for their communication.

The baud rate set on the relay only affects the rate at which the relay communicates with the modem. Similarly, the baud rate set in HyperTerminal only affects the rate at which the computer communicates with its modem. Details on how to set these respective baud rates are described above, except that the user modifies the Port 123 baud rate on the relay and the properties of the modem in HyperTerminal.

# 2.12 Accessing the Relays SCADA Services

The relay supports DNP3 (Level 2) and Modbus SCADA protocols as a standard feature on all ERLPhase relays. DNP3 is available through a direct serial link (Port 122) or the Ethernet LAN on top of either TCP or UDP protocols. The Modbus implementation supports both Remote Terminal Unit (RTU) in binary or ASCII modes and is available through a direct serial link. The SCADA communication settings are made in B-PRO Offliner which can be accessed and uploaded to the B-PRO from Relay Control Panel.

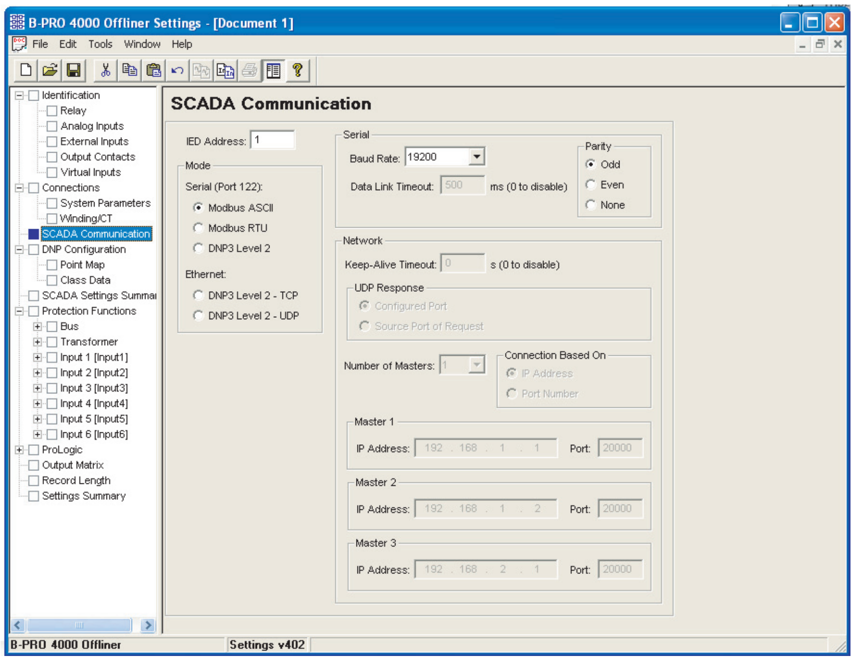



Figure 2.14: SCADA Communication B-PRO Offliner Settings Screen

B-PRO Port 122 is dedicated for use with Modbus or DNP3 serial protocols. Port 122 uses standard RS-232 signaling. An external RS-232↔RS-485 converter can also be used to connect to an RS-485 network.

For details on connecting to serial Port 122 see “Communicating with the Relay Intelligent Electronic Device (IED)” on page 2-3 and “Communication Port Details” on page 2-17.

The DNP3 protocol can also be run across the optional Ethernet LAN. Both DNP over TCP and DNP over UDP are supported. For details on connecting to the Ethernet LAN see “Network Link” on page 2-7.

Complete details on the Modbus and DNP3 protocol services can be found in the Appendices. For details see “Modbus RTU Communication Protocol” in Appendix E and “DNP3 Device Profile” in Appendix F.

## Protocol Selection

To select the desired SCADA protocol go to B-PRO 4000 Offliner SCADA communications section. Select the protocol and set the corresponding parameters.

## Communication Parameters

Port 122's communication parameters are set in the B-PRO 4000 Offliner SCADA communications section Both the baud rate and the parity bit can be configured. The number of data bits and stop bits are determined automatically by the selected SCADA protocol. Modbus ASCII uses 7 data bits. Modbus RTU and DNP Serial use 8 data bits. All protocols use 1 stop bit except in the case where either Modbus protocol is used with no parity; this uses 2 stop bits, as defined in the Modbus standard.

## Diagnostics

Protocol monitor utilities are available to assist in resolving SCADA communication difficulties such as incompatible baud rate or addressing. The utilities can be accessed through the Maintenance menu in VT100 Terminal mode.

# 2.13 Communication Port Details

**Table 2.4: Communication Port Details**

| Location | Port | Function |
|---|---|---|
| Front Panel | 119 | RJ-45 receptacle, 100BASE-T Ethernet interface. Default IP = 192.168.100.80<br>Used for user interface access or SCADA access through Ethernet LAN. |
| Front Panel | 150 | USB-B receptacle, High speed USB 2.0 interface<br>Used for user interface access<br>Default fixed baud rate 115,200 N81 (no parity, 8 data bits, 1 stop bit). |
| Rear Panel | 118 | RJ-11 receptacle, Internal modem interface.<br>Default Baud rate 38,400 N81 (no parity, 8 data bits, 1 stop bit) |
| Rear Panel | 119 | Rear panel, RJ-45 receptacle or ST type optical receptacle (factory configured). 100BASE-T or 100BASE-FX (1300nm, multimode) Ethernet interface. Same subnet as front panel port 119.<br>Used for user interface access or DNP SCADA access through Ethernet LAN |
| Rear Panel | 120 | RJ-45 receptacle or ST type optical receptacle (factory configured). 100BASE-T or 100BASE-FX (1300nm, multimedia) Ethernet interface.<br>Used for user interface access or DNP SCADA access through Ethernet LAN |
| Rear Panel | 121 | BNC receptacle, IRIG-B Interface. Modulated or un-modulated, 330 ohm impedance. |
| Rear Panel | 122 | RS-232 DCE female DB9.<br>Used for SCADA communication.<br>Default Setting: 19,200 baud O71 (odd parity, 7 data bits, 1 stop) |

**Table 2.4: Communication Port Details**

| | | |
|---|---|---|
| Rear Panel | 123 | RS-232 DCE female DB9.<br>Used for:<br>• User interface access through a direct serial connection.<br>• Default Setting: 9600 baud N81 (no parity, 8 data bits, 1 stop bit).<br>• User interface access through an external modem. The optional ERLPhase Modem Adapter converts this port to a Data Terminal Equipment (DTE) to simplify connection to an external modem. |

**Table 2.5: Signal Connections to Pins on Relay Port**

| Signal Name | Direction PC<-> Relay | Pin # on the Relay Port |
|---|---|---|
| DCD | ← | 1 |
| RxD | ← | 2 |
| TxD | → | 3 |
| DTR | → | 4 |
| Common | | 5 |
| DSR | ← | 6 |
| RTS | → | 7 |
| CTS | ← | 8 |
| No connection | | 9 |

Notes:
- Relay is DCE, PC is DTE
- Pins 1 and 6 are tied together internal to the relay

| Table 2.6: Cable Pin Connections | |
|---|---|
| **Male DB-9 Cable End for Relay Port** | **Female DB-9 Cable End for Computer Port** |
| Pin # on Cable | Pin # on Cable |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |
| 4 | 4 |
| 5 | 5 |
| 6 | 6 |
| 7 | 7 |
| 8 | 8 |
| 9 | 9 |

| Table 2.7: Signal Name Connections to Pins on Modem Adapter | | |
|---|---|---|
| **Signal Name** | **Direction Modem <-> Relay** | **Pin # on the Modem Adapter** |
| DCD | → | 1 |
| RxD | → | 2 |
| TxD | ← | 3 |
| DTR | ← | 4 |
| Common | | 5 |
| DSR | → | 6 |
| RTS | ← | 7 |
| CTS | → | 8 |
| No connection | | 9 |

Notes:
- Relay (with modem adapter) is DTE, modem is DCE
- Pins 1 and 6 are tied together internal to the relay

# 3 Using the IED (Getting Started)

## 3.1 Introduction

This section provides information on the start-up sequence and ways to interface with the relay. Descriptions of the Front Panel Display and Metering Data are provided.

## 3.2 Start-up Sequence

When the power supply is connected, the following initialization initializing sequence takes place:

**Table 3.1: Initialization Sequence**

| | |
|---|---|
| TEST MODE—red LED on | when power applied |
| RELAY FUNCTIONAL—green LED on | within 5 seconds after power applied |
| TEST MODE—red LED off then on | within 10 seconds |
| Front Display—on | on within 20 seconds after power applied |
| TEST MODE—red LED off | within 20 seconds after power applied |

When the Relay Functional LED comes on, it indicates that the Digital Signal Processor (DSP) is actively protecting the system.

When the test mode LED goes off, the relay is capable of recording and communicating with the user

## 3.3 Ways to interface with the Relay:

- Front panel display
- Terminal mode (for maintenance and firmware upgrade)
- Relay Control Panel

# 3.4 Front Panel Display

The front panel display is the fastest and easiest way of getting information from the relay.


Figure 3.1: Front Panel Display

The display, the 16 LED lights and the 6 push buttons, provide selective information about the relay.

## LED Lights

| Table 3.2: Description of LED Lights | |
|---|---|
| Relay Functional | When LED is illuminated, indicates that the relay is functional. When the Relay Functional green LED first illuminates, the Relay Inoperative normally closed contact Opens and the protective functions become active. |
| IRIG-B Functional | When LED is illuminated, indicates the presence of a valid IRIG-B time signal. |
| Service Required | When LED is illuminated, indicates the relay needs service. This LED can be the same state as the Relay Functional LED or can be of the opposite state depending on the nature of the problem.<br>The following items bring up this LED:<br>DSP failure - protection difficulties within the relay.<br>Communication failure within the relay.<br>• Internal relay problems. |
| Test Mode | Illuminates when the relay output contacts are intentionally blocked.<br>• Possible reasons are:<br>• Relay initialization on start-up<br>User interface processor has reset and is being tested.<br>The user cannot communicate with the relay through the ports until the front display becomes active and the TEST MODE LED goes out.<br>Normally, the red Target LEDs will be off after the start-up unless the relay had unviewed target messages prior to losing power. |

| Table 3.2: Description of LED Lights | |
|---|---|
| Alarm | Illuminates when an enabled relay function picks up.<br>The red Alarm LED should be off if there are no inputs to the relay. If the Alarm LED is on, check the event log messages or *Metering>Logic>Protection Logics* from the front display or on your computer in Relay Control Panel. |
| **Target LEDs** | **Descriptions** |
| 1 – 11 | Each of the 11 target LEDs is user configurable for any combination of Protection trips or ProLogic element operation. |

## Push Buttons

| Table 3.3: Identification of Push Buttons | |
|---|---|
| Up, Down, Right, Left, Enter, Escape | Used to navigate the front panel screens. |

## Display

The basic menu structure for navigation of the LCD screen is given below:

| Table 3.4: Navigation of the LCD Screen | | | | | | |
|---|---|---|---|---|---|---|
| Main Screen | | | | | | |
| | View / Change / Service : Choice Menu | | | | | |
| | | Enter Password | | | | |
| | | Main Menu | | | | (V, C, S) |
| | | | System | | | (V, C, S) |
| | | | | Relay Identification | | (V, C, S) |
| | | | | Relay Comm Setup | | (V, C, S) |
| | | | Metering | | | (V, C, S) |
| | | | | Analog | | (V, C, S) |
| | | | | | Analog Inputs | (V, C, S) |
| | | | | | Line Quantities 1 | (V, C, S) |
| | | | | | Line Quantities 2 | (V, C, S) |
| | | | | | 87B Operating | (V, C, S) |
| | | | | | 87T Operating | (V, C, S) |
| | | | | External Inputs | | (V, C, S) |
| | | | | Output Contacts | | (V, C, S) |
| | | | | Logic | | (V, C, S) |
| | | | | | Logic Protections 1 | (V, C, S) |
| | | | | | Logic Protections 2 | (V, C, S) |

**Table 3.4: Navigation of the LCD Screen**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Logic Protections 3 | | (V, C, S) |
| | | | | ProLogic | | (V, C, S) |
| | | | | V, C, Virtual Inputs | | (V, C, S) |
| | | Records | | | | (V, C, S) |
| | | | V, C, View Record List | | | (V, C, S) |
| | | | Fault Recording | | | (C,S) |
| | | | Swing Recording | | | (C,S) |
| | | | Event Recording | | | (C,S) |
| | | Event Log | | | | (V, C, S) |
| | | Utilities | | | | (V, C, S) |
| | | | Setup | | | (V, C, S) |
| | | | | Timeouts | | (V, C, S) |
| | | | | Time Settings | | (V, C, S) |
| | | | | Set Manual Time | | (V, C, S) |
| | | | | Set DST Time | | (V, C, S) |
| | | | Maintenance | | | (V, C, S) |
| | | | | Output Contacts Control | | (S) |
| | | | | Virtual Inputs Control | | (C,S) |
| | | | | Erase | | (C,S) |
| | | | | | Erase Records | (C,S) |
| | | | | | Erase Event Logs | (C,S) |
| | | | Network | | | (V, C, S) |
| | | | | Network Protocol Stats | | (V, C, S) |
| | | | | Active Sockets | | (V, C, S) |
| | | | | Routing Tables | | (V, C, S) |
| | | | | Ping | | (V, C, S) |
| | | Logout | | | | (V, C, S) |

Where the access levels required to access each are indicated by:

V: view
C: change
S: service

To login into the LCD menu structure, follow these steps:


Figure 3.2: Main Screen

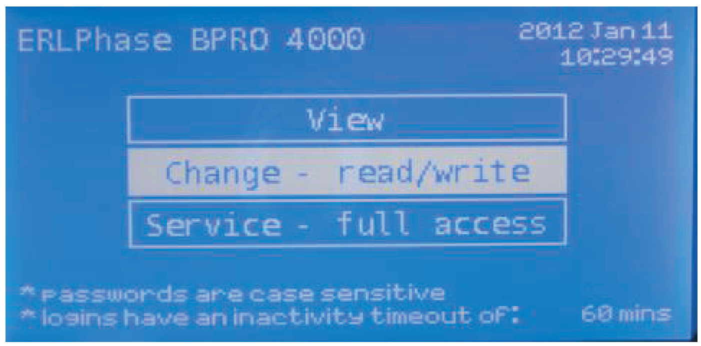



Figure 3.3: View / Change / Service: Choice Menu


Figure 3.4: Enter Password

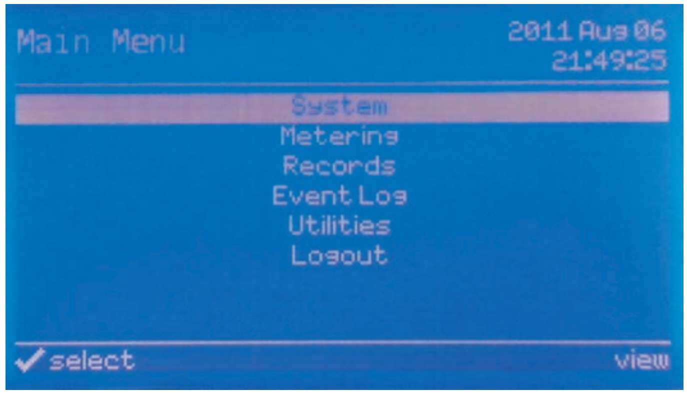



Figure 3.5: Main Menu

In the Main Screen, hit *Enter*.

In the View / Change / Service: Choose Menu screen, choose desired access level, hit *Enter*.

In the Enter Password screen, enter appropriate password, hit *Enter* on the return character (right bottom one)

The Main Menu screen should appear.

Note: The default passwords are (remove quotation marks)

View Access “view”

Change Access “change”

Service Access “service”

# 3.5 Relay Control Panel

RCP is used for all user interface. A short description of the RCP configuration to connect to a relay is given here. Please refer to the Relay Control Panel User Manual for details.

Follow this sequence to configure RCP for USB link to the relay.

1. Execute.

   *Relay Control Panel.exe*
2. Execute.

   *B-PRO 4000 Offliner.exe*
3. Install Null Modem Driver.

   Please refer to the Relay Control Panel User Manual for details.
4. Run Relay Control Panel.

   Go to:

   *Start > All Programs > ERLPhase > Relay Control Panel > Relay Control Panel*

   First time RCP is run.

   Hit *Add New*.

   "Add New Relay"

   Choose *Communication > Direct Serial Link*.

   Hit *Get Information From Relay.*

   Then RCP will communicate with the BPRO-4000 and retrieve information to fill required fields.

   When this is done, hit *Save Relay*.

   If the window "Relay already exists..." pops up, you may need to rename the relay changing the "Relay Name" in the "Relay Definition" category, before saving.

   After first time, in "Select Relay", choose relay and hit *Connect*.

   In "Relay Password Prompt"

   Choose desired access level, enter appropriate password

   Note: Default passwords are listed below (remove the quotation marks)

   View Access "view"

   Change Access "change"

   Service Access "service"

   The basic structure of the Relay Control Panel information, including basic actions available, is given below:

**Table 3.5: Relay Control Panel Structure**

| | | | View | Change | Service |
|---|---|---|---|---|---|
| Relay Control Panel | | | | | |
| | Records | | | Trigger Fault | Trigger Fault |
| | | | | Trigger Swing | Trigger Swing |
| | | | | Trigger Event | Trigger Event |
| | | | | | |
| | Events | | | Erase | Erase |
| | | | | | |
| | Metering | | | | |
| | | Analog | | | |
| | | Line | | | |
| | | External | | | |
| | | Protection | | | |
| | | ProLogic | | | |
| | | Outputs | | | |
| | | Group Logic | | | |
| | | Virtual | | | |
| | | | | | |
| | Utilities | | | | |
| | | Unit Identification | | | |
| | | Communication | | | |
| | | Time | | | |
| | | Analog Input Calibration | N/A | N/A | |
| | | External Input | | | |
| | | Virtual Inputs | N/A | Latch/Pulse | Latch/Pulse |
| | | Toggle Outputs | N/A | N/A | Close/Open |
| | | Settings Group | | Save | Save |
| | | Passwords | N/A | N/A | |
| | | | | | |
| | Configuration | | | | |
| | | Present Settings | (Get From Relay) | | |
| | | Saved Settings | | (Load to Relay) | (Load to Relay) |

# 4 Protection Functions and Specifications

# 4.1 Protection and Recording Functions

## Introduction

This section describes the equations and algorithms of the relay protection functions. All functions with time delay provide an alarm output when their pickup level is exceeded.

# 4.2 Differential Zone Selection and CT Input Assignment

The relay can be configured for a number of different differential zones. These zones are defined as:

- Bus 1
- Bus 1 and Transformer
- Transformer only
- Bus 1 and Bus 2

Bus1 zone allows up to 6 current inputs to be used in the bus differential zone (87B-1). All CT's used for bus protection must be wired in wye.

Bus 1 and transformer zone allows up to 5 current inputs to be used for the bus zone and 2 inputs for the transformer zone. In this configuration, Input 5 is used for both the bus zone and the transformer zone. Inputs 1-4 are used for the bus zone. Input 6 is used for the transformer zone only. Inputs 1-5 must be wired in wye, but input 6 can be wired in wye or delta.

Transformer only zone uses inputs 5 and 6 in the transformer differential zone (87T). Input 5 must be wired in wye, but input 6 can be wired in wye or delta.

Bus 1 and Bus 2 are used where 2 zones of bus differential protection are desired. In this case the maximum number of inputs that can be assigned to one zone is 4, with the minimum being 2. 87B-1 settings define the first differential zone and 87B-2 settings define the second.

In all cases, if a CT input will not be used, it should be set to "NC" or "not connected". This will remove this current input from any differential calculations. The CT input overcurrent functions and recording are still available.

# 4.3 Digital Control

Each CT input can be automatically excluded from all relaying, metering and recording functions based on the status of an associated external input. To set this feature, the Digital Control of the CT input must be enabled, the associated external input selected, and the state of “Exclude When” set. The CT input will be automatically excluded from all relaying, metering and recording functions when the status of the associated external input agrees with the “Exclude When” setting. This feature can be used to automatically adjust the CT inputs of a differential zone based on the changes in the bus configuration. The connections of “Exclude When” setting accommodates the use of “a” or “b” auxiliary contact as the digital control input.

# 4.4 Protection Function Descriptions

## Bus Protection

### 87B-1 Bus Differential (Bus1 differential zone only)

Device 87B-1 is the main protection of the bus. It will operate for the internal faults and restraint for the external faults. Up to 6 CT inputs can be configured as the inputs of 87B-1 and controlled by external inputs. If external control is enabled, and the corresponding external input is turned on, the ac analog current will be excluded from all relay metering and recording functions. There is no harmonic restraint provided for this function. Restraint quantities are summed; the magnitude sum is then divided by two. Operating quantities are summed vectors.

The slope characteristic is used with the input phase currents and with the input zero sequence currents. If either the phase current summation or the zero sequence input current summation enters into the slope characteristic, a High Mismatch indication will be generated.

The slope characteristic trip is supervised by the delta phase and the Rate of Change of Restraint and Operating (ROCOD) functions. These functions will be described in greater detail later in this section. Tripping of the 87B function will occur if the Io quantity goes into the operate region of the differential slope AND if the delta phase supervision OR the (ROCOD) function allows the trip to occur.

The current inputs of the B-PRO relay are normalized and summed to produce the restraint (Ir) and the operating (Io) quantities that are then used by the differential functions. Because the current transformers are restricted to being wye connected, the current summations can be done on a per phase basis.

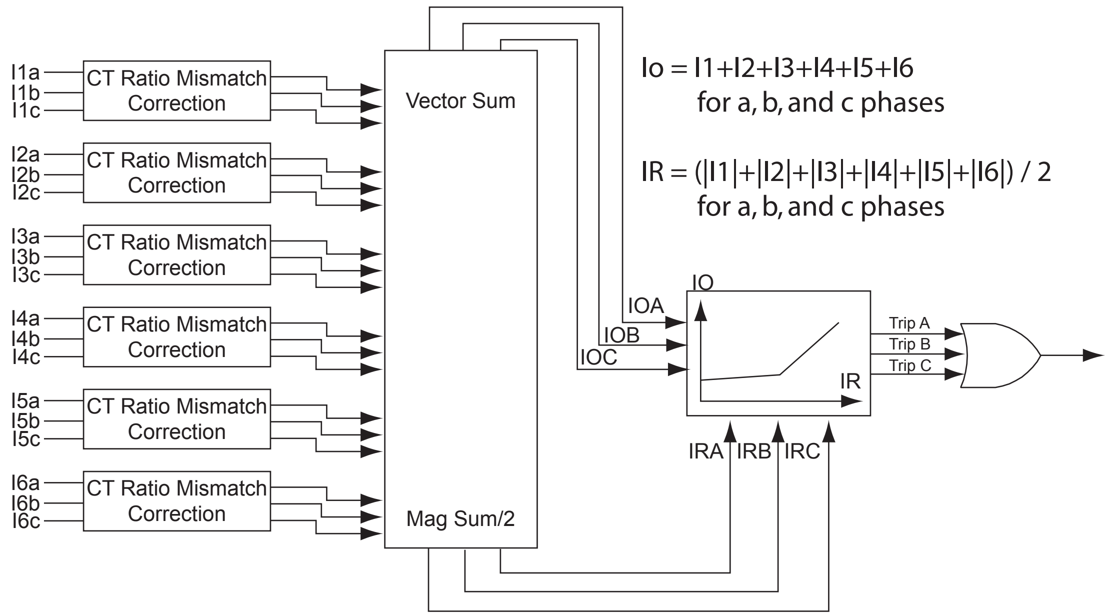



Figure 4.1: 87B-1 Bus Differential

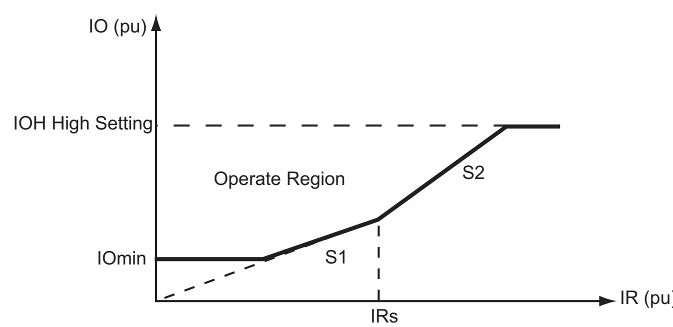



Figure 4.2: Bus Differential Characteristic

### Bus Differential Characteristic Settings

The bus differential slope incorporates user adjustable values for the S1, S2 slopes. The IRs setting is also user adjustable and is typically set above maximum bus transfer level. The $Io_{min}$ and the IOH (Hi Set trip) are user settable and define the minimum bus fault and the High set trip levels.

### CT Saturation Detector

A CT saturation detector has been incorporated into the B-PRO relay. This detector is applied automatically to the relay and does not require any user settings. The CT saturation detector detects all CT saturation conditions for external faults and blocks the differential protection from operating. It does not operate for internal faults.

### Detection of CT Saturation

Rather than examination of individual line fault currents for the presence of saturation, the detection method uses only IO and IR for its block/no-block decision. A novel algorithm (patent pending) has been developed to detect the fast CT saturation quickly, sensitively and accurately. The core of this algorithm is to check the phase relationship of dIO/dt and dIR/dt. For an internal fault, both IO and IR start to increase simultaneously and they are always kind of in phase. For an external fault, the phase dIO/dt is always lagging dIR/dt. The CT saturation function is always in place and no user settings are required.

### IOH High Set Trip

The IOH high set trip setting operates if the vector sum of the input currents (the operate current, Io) exceeds the setting value. There is no super- vision of this quantity but there is CT saturation detection control.

### IOH High Setting

There is no any intentional delay as long as the IO exceeds the IOH setting threshold no matter where the IO, IR trajectory comes from. The purpose of the IOH zone is to clear the extremely severe bus internal faults as soon as possible.

| Table 4.1: IOH High Setting | |
|---|---|
| $IO_{min}$ | Minimum level that device 87 operates |
| IRs | Point of intersection between slope 1 and slope 2 of the characteristic |
| S1 | Slope of first part of characteristic meeting $IO_{min}$ and slope 2 |
| S2 | Slope of second part of characteristic meeting slope 1 and high current unrestrained setting |
| IOH High Set | Heavy fault trip irrespective of restraint current. |

The differential relay has the following user setting ranges.

| Table 4.2: 87B Bus Differential | |
|---|---|
| $IO_{min}$ (pu) | 0.10 to 1.0 per unit |
| IRs (pu) | 0.6- 50 pu |
| S1 (%) | 20-100% |
| S2 (%) | 30-200% |
| High Current Setting (pu) | 1-100 per unit |
| Bus Base MVA | Set in System Parameters |

## Overall Device 87 Function

The bus differential protection for 87B1 and 87B2 consists of:

1 A slope function that an 87 function uses to determine faults. Phase angle comparisons and rate of change of the operate and restraint currents are done to determine if the faults are on the bus or external to the bus. Bus faults result in phase currents that are within 90 degrees or less of each other.

2 A high set differential function that trips for high internal fault current conditions. This function is supervised by the CT saturation detector.

3 A summation of 3Io from the CTs is done. If this quantity is greater than $Io_{min}$, and if the phase angles of the quantities are within 90 degrees of each other, this function is allowed to trip if the slope characteristic also picks up.

For details see Figure 4.3: Bus Differential Logic on page 4-6.

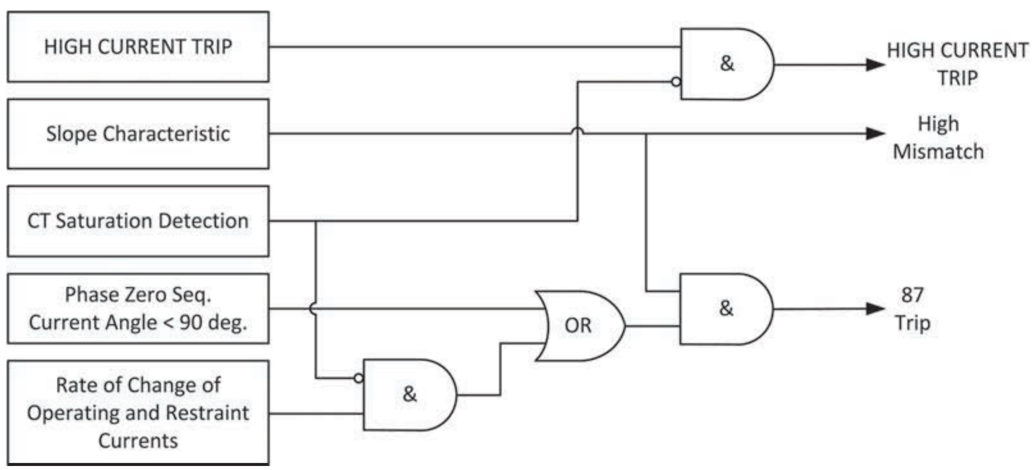



Figure 4.3: Bus Differential Logic

### Delta Phase Supervision (Patent Pending)

The differential functions in B-PRO are based on Kirchhoff's law that states that the currents in and out of a protected zone should add up to zero if no fault is present in this zone. The zone of protection defined by a differential relay is defined as the area between the current transformers.

The B-PRO differential functions for Bus 1, Bus 2 or a bus connected transformer use the vector summation of currents to develop an operating quantity called IO and a restraint quantity called IR which is simply the arithmetic sum of all current magnitudes divided by two. This defines the 87 slope characteristics.

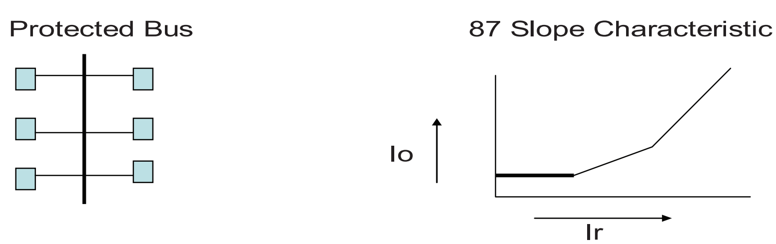



Figure 4.4: Delta Phase Supervision

During the operation of the power system faults can occur on the elements connected to the protected bus, but outside the bus protection zone.

These faults can produce large currents that will flow into the faulted element. Normally the summations of currents into and out of the protected bus should cancel out because the faulted element current is typically 180 degrees from the unfaulted currents in the other elements.

If the faulted element CTs are not able to effectively reproduce the fault current for the external fault, then unbalanced or IO current will increase and could cause the 87 function to misoperate for this external bus fault.

Studies for current transformers have revealed that the magnitude of the reproduced fault currents may become distorted in magnitude for external faults and can cause improper bus differential operation.

Studies of the CT performance during faults have revealed that although the magnitude may be distorted, the phase angle of the currents is largely unaffected by the faults. In other words, for internal bus faults the current contributions are largely in phase, while for external bus faults the faulted element current is typically 180 degrees out of phase with the non-faulted current contributions.

The delta phase supervision algorithm is provides security to the conventional slope characteristic differential function.

The delta phase supervision algorithm does not operate by itself, but functions as an additional supervision to the 87 slope characteristic only. If the slope characteristic operates, then the delta phase function determines if a bus trip is appropriate.

The delta phase supervision algorithm compares the angular relationship between all CT inputs on a phase by phase basis. If all current vectors are reasonably in phase, this is an indication that a bus fault is occurring. If on the other hand, one or more current inputs are opposite to the rest, this is an indication that an external fault is present.

The comparison between the current input phase angles is done continuously in real time using the mathematical dot product calculations.

The dot product of two vectors is simply the projection of one vector on another. In mathematical terms, if Vector A and Vector B are considered, A * B = AB Cos (theta), where theta is the angle between the two vectors. This concept makes use of the angular relationship present in Kirchhoff's current law.

For angles of "theta" less than 90 degrees, and with the A and B vectors normalized to a value of one, the dot product will be zero at 90 degrees and > zero if less than 90 degrees. If the angle is greater than 90 degrees, the dot product will be negative in value.

Figures below illustrate bus load transfer, internal bus fault and external bus fault input current angle comparisons.

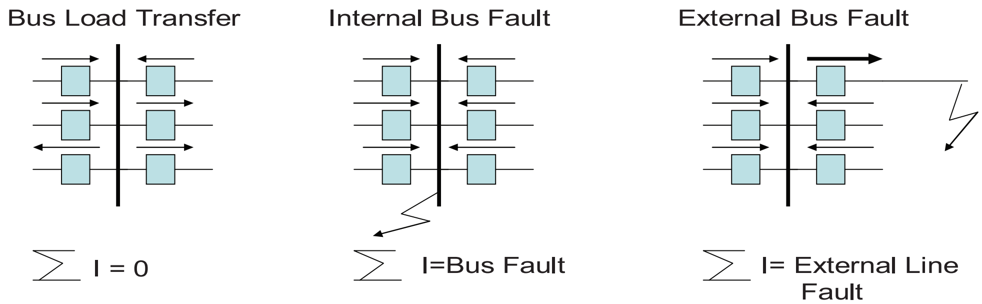



Figure 4.5:

For the load bus transfer case, the vector currents in and out of the bus add to zero.

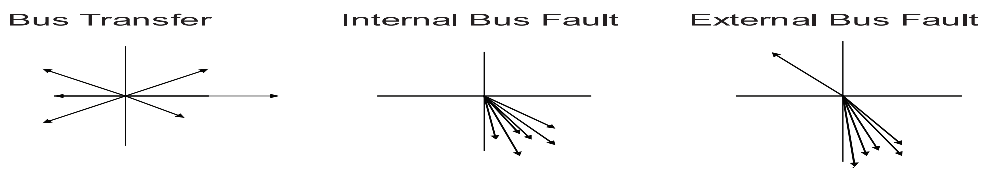



Figure 4.6:

The delta phase supervision algorithm calculates the angle difference between the current vectors on the same phase. If the maximum angle between any two current phases is greater than 90 degrees, the fault is identified as an external fault and blocking of the 87 slope differential occurs.

The currents for an external fault are close to 180 degrees apart between the faulted phase current and the non-faulted phase currents. There could be CT phase angle errors, however, so the boundary condition has been set to 90 degrees to take into account any CT angle errors. This boundary is fixed and has no user settings associated with it.

To verify that the CT current angle is accurate a current level detection fixed at 0.25 A for 5 A nominal and 0.05 A for 1 A nominal secondary is present for each current input. If the AC current input is below this value, the current phase angle will not be calculated. If only one current input above this current threshhold is found, the delta phase algorithm will not inhibit 87 slope tripping if required. This means that if a bus fault occurs and the bus is attempted to be supplied from one source, the differential relay will trip.

### Rate Of Change Of Derivative Function (ROCOD)

For some internal fault cases where a radial load may be present on the low side or on the tertiary side of the transformer, a high resistance ground fault may not cause the load current to change. As a result delta phase may not be able to operate until the fault resistance becomes low.

To cater to this condition, a rate of change of the operating and the restraint current is performed. It has been found that for internal faults the positive magnitude of the operating current derivative will always exceed the positive value of the restraint current derivative. If this condition occurs, this ROCOD function allows the slope function to trip. If the fault is external to the differential zone, the positive value of the operating current will not exceed the positive value of the restraint current.

The ROCOD function is therefore in place to add sensitivity to the differential relay for internal faults.

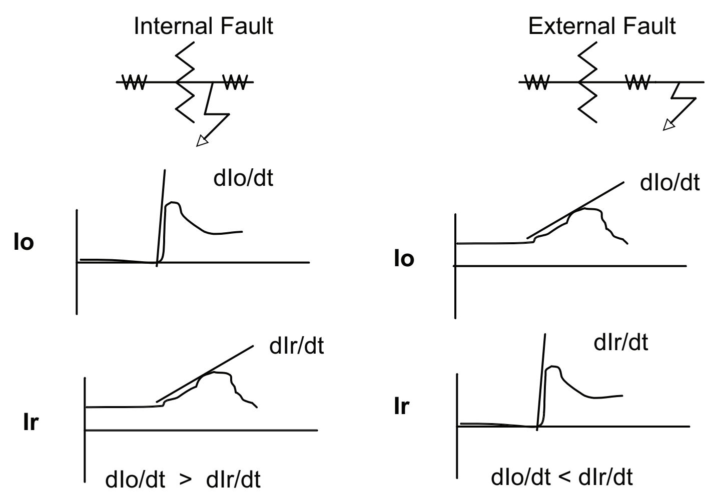



Figure 4.7: Rate Of Change Of Operating And Restraint Quantities

Figure 4.7: Rate Of Change Of Operating And Restraint Quantities on page 4-9 shows how the dio/dt and the dIr/dt quantities occur during an internal and during an external fault.

For an internal fault, the dIo/dt quantity will always be greater than the dIr/dt quantity. When this happens, ROCOD generates a positive logic that will allow the slope function to generate a relay trip. On the other hand, if an external fault occurs, dIo/dt will always be less than dIr/dt. This in turn will prevent operation of ROCOD and thus prevent operation of a differential trip.

## 87B-2 Bus Differential

The 87B-2 is used to define the second bus differential zone. The 87B-2 is only available when the Differential Zone is selected as Bus1 and Bus2. Up to 4 CT inputs can be assigned to the 87B-2. The 87B-2 settings are the same as the 87B-1.

## 59 Overvoltage

Two sets of overvoltage protection elements are provided to monitor the bus voltage. The 59-1 and 59-2 functions are identical in terms of operation. Use the gate switch to select between an “AND” or an “OR” gate. Use an “AND” gate to detect 3-phase overvoltage condition; use an “OR” gate to detect any phase overvoltage condition. The definite time delay can be set to 0.0 for a instantaneous output.

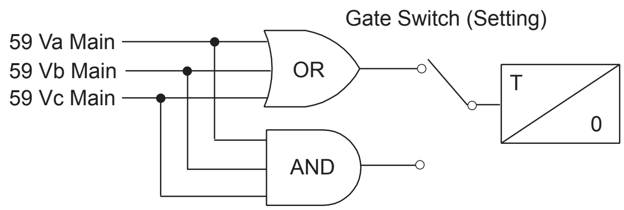



Figure 4.8: 59 Overvoltage

| Table 4.3: 59 Overvoltage Settings | |
|---|---|
| Gate Switch | AND or OR |
| Pickup (Volts Sec.) | 60.0 to 138.0 |
| Pickup Delay (seconds) | 0.00 to 99.99 |

## 27 Undervoltage

Two sets of undervoltage protection elements are provided to monitor the bus voltage. The 27-1 and 27-2 functions are identical in terms of operation. Use the gate switch to select between an “AND” or an “OR” gate. Use an “AND” gate to detect 3-phase undervoltage condition; use an “OR” gate to detect any phase undervoltage condition. The definite time delay can be set to 0.0 for a instantaneous output.

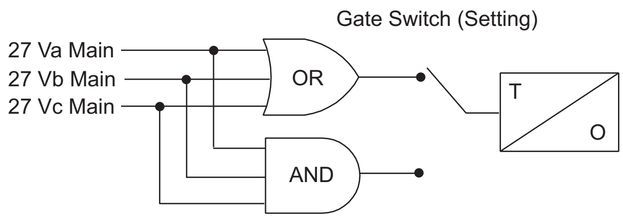



Figure 4.9: 27 Undervoltage

| Table 4.4: 27 Undervoltage Settings | |
|---|---|
| Gate Switch | AND or OR |
| Pickup (Volts Sec.) | 1.0 to 120.0 |
| Pickup Delay (seconds) | 0.00 to 99.99 |

## 60 Loss of Potential

This protection is to detect the loss of potential from either one or two phases, and issue an alarm.

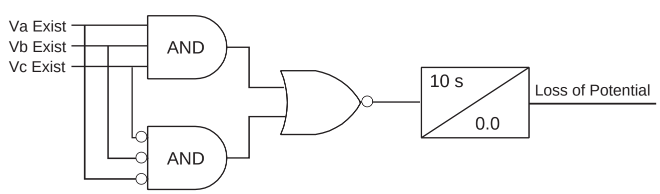



Figure 4.10: 60 Loss of Potential

Where Va_Exist = 1 if Va>0.5 pu, similar for Vb_Exist and Vc_Exist. Pickup time (= 10.0 seconds) and drop-out time (= 0.0 seconds) are fixed parameters.

1.0 pu is calculated as:

$$Vpusec = \frac{\text{Bus Voltage (Pri)}}{\sqrt{3}\text{x(PT Turns Ratio)}} \quad (1)$$

| Table 4.5: 60 Loss of Potential Settings | |
|---|---|
| Pickup Delay | 10 seconds (fixed) |

## 81 Over/Under Frequency

The relay provides two over frequency and two underfrequency protection elements which operate from the frequency of the Bus voltage inputs. Voltage from a potential transformer associated with the bus must be connected to the relay in order to utilize these functions. The 81 O/F-1 and 81 O/F-2 functions are identical in terms of operation. Any positive sequence overfrequency condition produces an output. Undervoltage inhibit is provided and fixed at 0.25 pu of nominal system voltage.

The relay provides two under frequency elements which are ideal for under frequency load shedding applications. The 81 U/F-1 and 81 U/F-2 functions are identical in terms of operation. Any positive sequence underfrequency condition produces an output. Undervoltage inhibit is provided and fixed at 0.25 pu of nominal system voltage.

The 81 frequency elements operate and produce an output using a definite time delay function. The overall time delay will be the user setting, an additional inherent delay from 1.25 cycles to 1.75 cycles, and an additional +- 3 ms operate time for the output contact. The element will have a total operate time of under 5 cycles when set to the minimum time delay setting of 0.05 seconds.

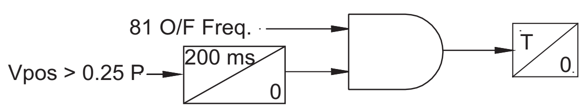



Figure 4.11: 81 O/F Over Frequency

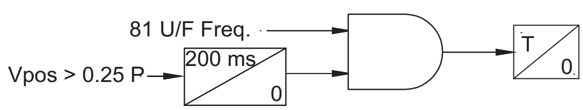



Figure 4.12: 81 U/F Under Frequency

| Table 4.6: 81 Over/Under Frequency Settings | |
|---|---|
| Pickup (Hz) | 60.0 to70.0 / 50.0 to 60.0 (60 Hz)<br>50.0 to 60.0 / 40.0 to 50.0 (50 Hz) |
| Pickup Delay (seconds) | 0.05 to 99.99 (inherent delay of 1.25 to 1.75 cycles, depending on frequency step change) |

# 4.1 Transformer Protection

## 87T Transformer Differential

Device 87T is the differential protection for the transformer zone. It can be used when the differential zone is selected as Bus1 & Transformer or Transformer Only. The device operates for internal faults and provides restraint for external faults, transformer energization or transformer over excitation conditions. CT input 5 and CT input 6 are dedicated for the differential device when 2 differential zones (bus and transformer) are selected, or if only 1 differential zone (transformer) is selected. If external input control is enabled, and asserted, the ac analog current will be excluded from all relay, metering and recording functions.

Restraint magnitudes are summed; the magnitude sum is then divided by two. Operating quantities are summed vectors.

Device 87T has 2nd and 5th harmonic blocking, each element is set independent of each other. If an input phase current is less than 5% of $I_{nominal}$, this current will not be used for the 2nd and 5th harmonic blocking calculation. For a 5 A relay this equals 0.25 A.

As shown below, the 2nd harmonic's restraint signal is 5 for 5 ms in the first cycle on transformer energization to prevent the 2nd harmonics restraint signal from any possible momentary reset due to the current signal transition in the first cycle. Note that this logic only becomes active when the transformer has been de-energized or very lightly loaded (the restraint current is less than 30% of $IO_{min}$ setting)

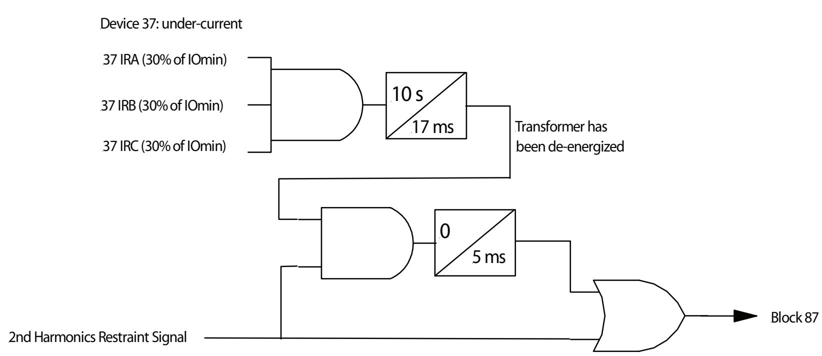



Figure 4.13: 87T Transformer Differential

| Table 4.7: 87T Transformer Differential Settings | |
|---|---|
| $IO_{min}$ | Minimum level that device 87 operates |
| IRs | Point of intersection between Slope 1 and Slope 2 of the characteristic |
| S1 | Slope of first part of characteristic meeting IO min and Slope 2 |

| Table 4.7: 87T Transformer Differential Settings | |
|---|---|
| S2 | Slope of second part of characteristic meeting Slope 1 and high current unrestrained setting |
| I2 | Ratio of 2nd harmonic current to fundamental, used to provide energizing harmonic restraint |
| I5 | Ratio of 5th harmonic current to fundamental, used to provide restraint on over excitation |
| IOH High Set | Unrestrained high set overcurrent, operates if a heavy fault occurs on the transformer irrespective of restraint |

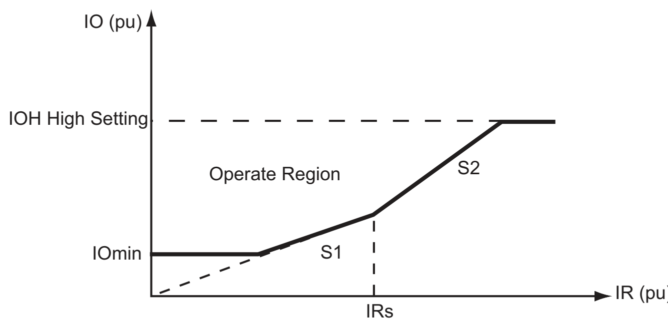



Figure 4.14: Transformer Differential Protection Characteristic

| Table 4.8: 87T Transformer Differential | |
|---|---|
| $IO_{min}$ (pu) | 0.2 to $\left(\frac{IRs \times S1}{100}\right)$ |
| IRs (pu) | $\left(IOmin \times \frac{100}{S1}\right)$ to 50.00 |
| S1 (%) | $\left(IOmin \times \frac{100}{IRs}\right)$ to Min (S2, 100) |
| S2 (%) | Max (S1, 30) to 200.00 |
| High Current Setting (pu) | $IOmin \times 3$ to 100.00 |
| I_2nd/I_fund Ratio | 0.05 to 1.00 |
| I_5th Restraint Enabled | Enable/Disable |
| I_5th/I_fund Ratio | 0.05 to 1.00 |
| Transformer Base MVA | Set in Winding/CT Connections |

# 4.2 Inputs 1 to 6 Protection

## 50LS Low Set

Two sets of definite time delay overcurrent protection functions on each CT input provide non-directional current detection. The 50LS-1 and 50LS-2 functions are identical in terms of operation. Use the gate switch to select between an “AND” gate or an “OR” gate. Use an “AND” gate to detect 3-phase overcurrent condition; use an “OR” gate to detect any phase overcurrent condition. The definite time delay can be set to 0.0 for a instantaneous output.

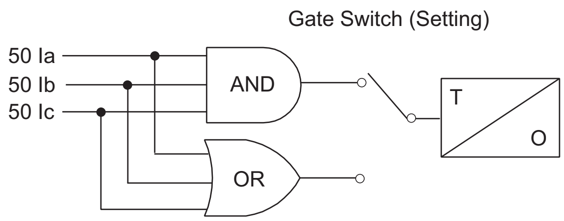



Figure 4.15: 50LS Low Set

| Table 4.9: 50LS Low Set Overcurrent Settings | |
|---|---|
| Gate Switch | AND or OR |
| Pickup (Amps Sec.) | 0.1 to 50.0 (5 A)<br>0.02 to 10.00 (1 A) |
| Pickup Delay (seconds) | 0.00 to 99.99 |

## 50BF Breaker Failure

Breaker failure protection function is used to detect breaker failures and react correspondingly. This function is provided on all the current inputs. When breaker failure is initiated by a trip (user-settable: include 87B-1, 87B-2, 87T, ProLogic, External Input or its own O/C functions) and the breaker current still exists, two timers (T1 and T2, user settable) will be started. After these timers are timed out, if the current still exists (which indicates breaker failure), the output of this function will be set high.

Referring to Figure 4.16: 50BF Breaker Failure on page 4-16, the 2 outputs of the Breaker Fail function can be used for backup tripping via the secondary breaker trip coil (if applicable) or to trip the next level of breakers, such as the bus breakers.

For example, the user may set T1 to 50 ms and T2 to 200 ms. Use the output of T1 to attempt to trip the slow or failed breaker via its secondary trip coil. The user may also use T1 to initiate a “slow breaker” alarm to initiate maintenance checks.

If T1 was not successful in tripping the breaker, then T2 will time out and trip all the breakers adjacent to the failed breaker. However, if the breaker trips suc-

cessfully via T1, the current will instantly go to zero and a trip of the entire bus or transformer zone will be avoided.

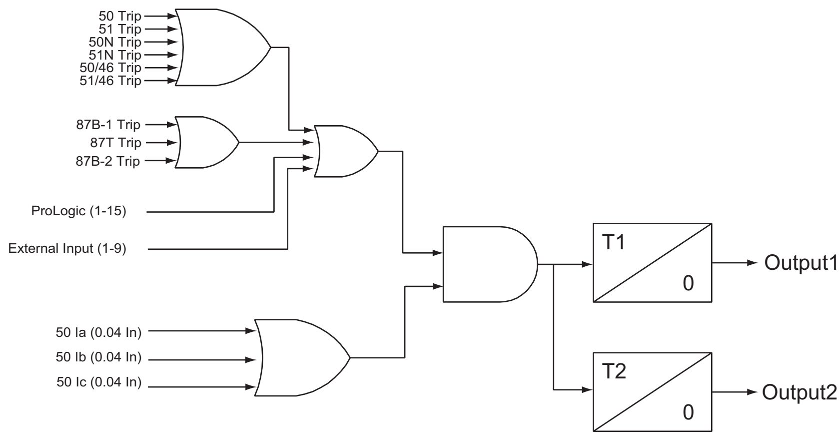



Figure 4.16: 50BF Breaker Failure

| **Table 4.10: 50BF Breaker Fail Settings** | |
|---|---|
| Breaker Failure Initiated by 87B-1 | Enable/disable |
| Breaker Failure Initiated by 87B-2 | Enable/disable |
| Breaker Failure Initiated by 87T | Enable/disable |
| Breaker Failure Initiated by ProLogic | ProLogic 1 to ProLogic 15 |
| Breaker Failure Initiated by External Input | External Input 1 to External Input 9 |
| Pickup Delay 1 (seconds) | 0.01 to 99.99 |
| Pickup Delay 2 (seconds) | 0.01 to 99.99 |

# 67 Directional Element

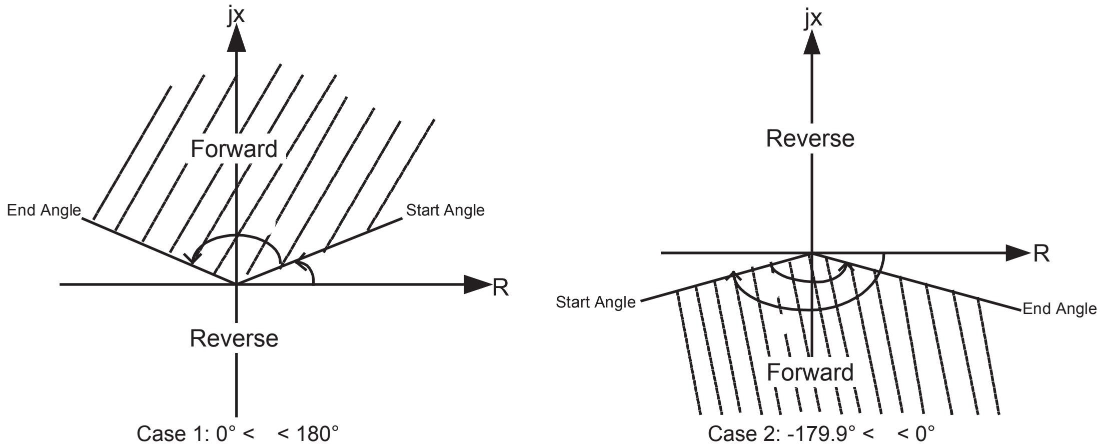



Figure 4.17: 67 Directional Element

The directional element Forward direction is determined by two user-defined Positive Sequence Impedance angle setting parameters: "Alpha" and "Beta", which are located in the System Parameters setting screen. These two parameters are universal; they are utilized by all inputs.

The positive sequence impedance angle for any particular relay input is its own measured positive sequence Current angle, subtracted from the bus positive sequence memory voltage angle.

Simply stated, the Forward Range:

- Starts at Alpha (Alpha can be any angle from -179.9° to +180°).
- Ends at Alpha + Beta (Beta, is the scope of the range and can only be positive, +0.1° to +360°).

The above figure does not show recommended settings, but it clearly illustrates the affect of Alpha and Beta settings in the (±R±jX) impedance plane. In each case, the shaded area shall be the defined Forward direction to be used by all 67 elements.

- In example Case 1, the Forward impedance angle appears to be centred at +90°. The forward range starts at +20° and ends at +160° (i.e., Alpha = +20°, and Beta = +140°).
- In example Case 2, the Forward impedance appears to be centred at -90°. The forward range starts at -160° and ends at -20° (i.e., Alpha = -160°, and again Beta = +140°).

An important consideration for setting the Directional Element is to ensure that the CT polarity convention is observed in defining the forward direction. When the relay is used primarily for bus protection, the relay will normally be connected as in Figure 1.1: on page 1-2, Figure 1.2: on page 1-3 and Figure 1.3: on page 1-4. Therefore, the 87B function normally has the CT "0° connection"

defined for current flowing into the bus rather than away from the bus. This opposes the expected connection of the Line Protection relay.

So, if the relay current connections are similar to those of Chapter 1, and if the user is setting directional overcurrent elements to declare Line faults as Forward faults (to match the directional convention of the Line Protection relay), then the Alpha and Beta settings would be expected to be closer to Figure 4.17: 67 Directional Element on page 4-17. Case 2, in the -jX range. Typical settings in this scenario may be: Alpha = +170°, Beta = +170°, which would center a 170° forward range around the +255° impedance angle, for a typical (approximate) 75° Line angle.

There is great flexibility in the Alpha and Beta settings so it can be tailored for correct directional control based on the studies of all fault types. To properly select Alpha and Beta, ensure that the user observes the Positive Sequence Current Angle for all fault simulations, referred to the prefault Positive Sequence (Memory) Voltage Angle. This way the user can ensure proper directional decision for all forward and reverse faults. The user can also make all overcurrents non-directional by setting Beta = +360°, in which case all faults will be "forward".

## 50/51/67 Phase Overcurrent

Phase overcurrent provides backup protection to the differential protection. This function operates on fundamental quantities of the highest phase current of the 3 phases. Two sets of phase time overcurrent protection functions on each CT input provide directional or non-directional current detection. There is a definite time overcurrent element (50) and an inverse time overcurrent element (51). The user can configure both 50 and 51 to be non-directional, forward direction, or reverse direction sensitive. The user can also configure both 50 and 51 outputs to initiate the 50BF protection element. Device 51 provides three predefined IEEE, three IEC inverse time curves, and one user-defined curve. The equation and the parameters of device 51 are listed below. The user can select the user-defined curve type and the parameters in the equation are settable otherwise they are fixed and determined by the curve type.

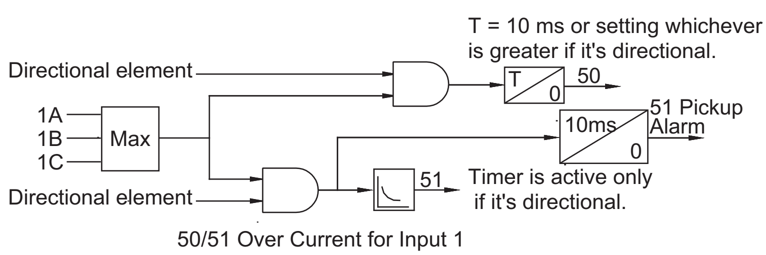



Figure 4.18: 50/51/67 Phase Overcurrent

When the threshold for pickup of the relay is exceeded, the function 51 alarm will pickup indicating the relay has commenced timing.

| Table 4.11: IEC and IEEE Curves | | | | | |
|---|---|---|---|---|---|
| # | Characteristic | A | B | p | tr |
| 1 | IEC Standard Inverse | 0.14 | 0 | 0.02 | 13.5 |
| 2 | IEC Very Inverse | 13.5 | 0 | 1.0 | 47.3 |
| 3 | IEC Extremely Inverse | 80.0 | 0 | 2.0 | 80.0 |
| 4 | IEEE Moderately Inverse | 0.0103 | 0.0228 | 0.02 | 0.97 |
| 5 | IEEE Very Inverse | 3.922 | 0.0982 | 2.0 | 4.32 |
| 6 | IEEE Extremely Inverse | 5.64 | 0.0243 | 2.0 | 5.82 |
| 7 | User-defined | 0.0010 to 1000.0 | 0.0000 to 10.000 | 0.01 to 10.0 | 0.10 to 100.00 |

Pickup: For I > Pickup

$$T(I) = TMS\left(B + \frac{A}{\left(\frac{I}{Pickup}\right)^{p} - 1}\right) \tag{2}$$

Reset: For I < Pickup

$$T(I) = TMS\left(\frac{TR}{\left(\frac{I}{Pickup}\right)^{2} - 1}\right) \tag{3}$$

| Table 4.12: 50/51/67 Phase Overcurrent Settings | |
|---|---|
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5 A)<br>0.1 to 10.0 (1 A) |
| Pickup Delay | 0.00 to 99.99 |
| 50 Breaker Failure Initiated | enabled or disabled |
| 51 Enabled | enabled or disabled |
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5 A)<br>0.1 to 10.0 (1 A) |

| Table 4.12: 50/51/67 Phase Overcurrent Settings | |
|---|---|
| Curve Type | For details see Table 4.11: IEC and IEEE Curves on page 4-19. |
| TMS | 0.01 to 10.00 |
| A | 0.0010 to 1000.0000 |
| B | 0.0000 to 10.0000 |
| ρ | 0.01 to 10.00 |
| TR | 0.01 to 100.00 |
| 51 Breaker Failure Initiated | enabled or disabled |

## 50N/51N/67 Neutral Overcurrent

Neutral Overcurrent provides protection for phase to ground faults. This function operates on fundamental $3I_0$ residual quantities. Two sets of neutral time overcurrent protection functions on each CT input provide directional or non-directional current detection. There is a definite time overcurrent element (50N) and an inverse time overcurrent element (51N). The user can configure both 50N and 51N to be non-directional, forward direction, or reverse direction sensitive. The user can also configure both 50N and 51N outputs to initiate the 50BF protection element. Device 51N provides three predefined IEEE, three IEC inverse time curves, and one user-defined curve. The equation and the parameters of device 51N are listed below. The user can select the user-defined curve type and the parameters in the equation are settable otherwise they are fixed and determined by the curve type.

| Table 4.13: 50N/51N/67 Neutral Overcurrent Settings | |
|---|---|
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5 A)<br>0.1 to 10.0 (1 A) |
| Pickup Delay | 0.00 to 99.99 |
| 50N Breaker Failure Initiated | enabled or disabled |
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5 A)<br>0.1 to 10.0 (1 A) |
| Curve Type | For details see “IEC and IEEE Curves” on page 4-19. |
| TMS | 0.01 to 10.00 |

| Table 4.13: 50N/51N/67 Neutral Overcurrent Settings | |
|---|---|
| A | 0.0010 to 1000.0000 |
| B | 0.0000 to 10.0000 |
| ρ | 0.01 to 10.00 |
| TR | 0.01 to 100.00 |
| 51N Breaker Failure Initiated | enabled or disabled |

Pickup: For I > Pickup

$$T(I) = TMS\left(B + \frac{A}{\left(\frac{3Io}{Pickup}\right)^{p} - 1}\right) \quad (4)$$

Reset: For I < Pickup

$$T(I) = TMS\left(\frac{TR}{\left(\frac{3Io}{Pickup}\right)^{2} - 1}\right) \quad (5)$$

## 46-50/46-51/67 Negative Sequence Overcurrent

Negative Sequence Overcurrent provides further protection for any unbalanced faults. This function operates on fundamental $I_2$ negative sequence quantities. Two sets of negative sequence time overcurrent protection functions on each CT input provide directional or non-directional current detection. There is a definite time overcurrent element (46-50) and an inverse time overcurrent element (46-51). The user can configure both 46-50 and 46-51 to be non-directional, forward direction, or reverse direction sensitive. The user can also configure both 46-50 and 46-51 outputs to initiate the 50BF protection element. Device 46-51 provides three predefined IEEE, three IEC inverse time curves, and one user-defined curve. The equation and the parameters of device 46-51 are listed below. The user can select the user-defined curve type and the parameters in the equation are settable otherwise they are fixed and determined by the curve type.

| Table 4.14: 46-50/46-51/67 Negative Sequence Overcurrent Settings | |
|---|---|
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5 A)<br>0.1 to 10.0 (1 A) |
| Pickup Delay | 0.00 to 99.99 |

**Table 4.14: 46-50/46-51/67 Negative Sequence Overcurrent Settings**

| | |
|---|---|
| 46-50 Breaker Failure Initiated | enabled or disabled |
| Directional | non-directional, forward, reverse |
| Pickup | 0.5 to 50.0 (5 A)<br>0.1 to 10.0 (1 A) |
| Curve Type | For details see “IEC and IEEE Curves” on page 4-19. |
| TMS | 0.01 to 10.00 |
| A | 0.0010 to 1000.0000 |
| B | 0.0000 to 10.0000 |
| ρ | 0.01 to 10.00 |
| TR | 0.01 to 100.00 |
| 46-51 Breaker Failure Initiated | enabled or disabled |

Pickup: For I > Pickup

$$T(I) = TMS\left( (B + \frac{A}{\left(\frac{I2}{Pickup}\right)^{p} - 1} \right) \tag{6}$$

Reset: For I < Pickup

$$T(I) = TMS\left( \frac{TR}{\left(\frac{I2}{Pickup}\right)^{2} - 1} \right) \tag{7}$$

## ProLogic

The ProLogic control statements are used to create Boolean-like logic. The relay can use any of the protection functions, external inputs or virtual inputs combined with logic gates to create a ProLogic control statement. The output of a ProLogic statement can be nested in another ProLogic statement, so long as the ProLogic output that is to be nested is of lower order than the one in which it is to be nested. For example, ProLogic 5 can be used in ProLogic 7 but not vice-versa.

The possible gates are AND, NAND, OR, NOR, XOR, XNOR, and LATCH. The control can be time delay pickup and or time delay dropout, and can drive the front panel target LED. 15 ProLogic control statements outputs are available and can be used in the output matrix to customize the relay to the specific needs. Inputs to ProLogic can be all the elements, previous ProLogic statements for logic nesting usage, as well as External and Virtual Inputs.

The example shows A to E inputs are status points of devices that are user-selectable. Each ProLogic output can be given a specific name, pickup and rest time delay.

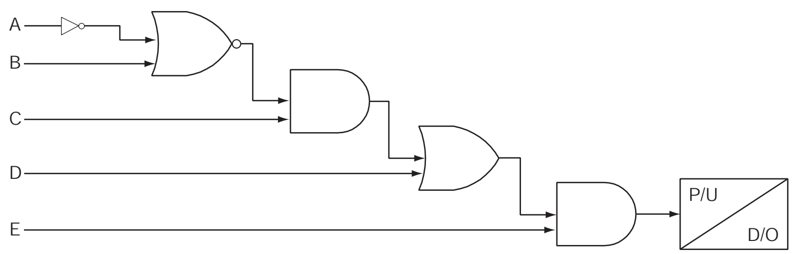



Figure 4.19: ProLogic

| Table 4.15: ProLogic Setting Functions | |
|---|---|
| Name | Give the ProLogic a meaningful name |
| Pickup Delay | Delay time from pickup to operate |
| Dropout Delay | Delay time from dropout to a ProLogic status of low |
| A, B, C, D, E | Relay elements as input statements |
| Operators | Boolean-type logic gates |

# 4.1 Recording Functions

The relay has recording and logging functions to aid with the analysis of faults, and the overall performance of the protection scheme.

## Fault Recording

The relay provides DFR-quality fault recording, capturing input signal waveforms and external input states at a rate of 96 samples per cycle. Each record also contains the timing of the internal logic produced by the relay (e.g. Device 87B-1 trip). Obtain this information by uploading the records from the relay via the Record Control Panel and view them with RecordBase View software.

The quantities recorded are:

- 21 analog channels (3 voltages and 18 currents, in secondary volts and amperes respectively) @ 96 samples/cycle
- 9 operational currents and 9 restraint currents @ 8 samples/cycle (87B-1, 87B-2, 87T IO+IR)
- 9 external inputs @ 96 samples/cycle
- Relay internal logic signals @ 8 samples/cycle, including virtual inputs
- 15 ProLogic signals @ 8 samples/cycle.

Parameters that are user-selectable with respect to recording faults:

- Record length (0.2–2.0 seconds => 12 – 120 cycles @ 60 Hz Base) with automatic extension to capture successive triggers
- Recorder triggering by any internal logic or external input signal

## Swing Recording

The relay records dynamic system responses allowing the user to analyze system stability and to provide a larger context for fault analysis. Swing records contain positive sequence phasor measurements and system frequency calculated at a rate of 1 phasor per cycle.

The quantities recorded are:

- Positive sequence impedance (magnitude)
- Positive sequence voltage (magnitude)
- Positive sequence current (magnitude)
- 3-Phase Vars (reactive power)
- 3-Phase Watts (real power)
- Positive sequence frequency

## Record Initiation

Recording can be initiated automatically by the relay when a fault or abnormal condition is detected. The user can set the relay to initiate a fault record on activation of any of its trip or alarm functions or on assertion of any external inputs.

The assignment of fault record initiation to the various relay functions is done through the relay's Output Matrix settings.

A recording can also be initiated manually through the Relay Control Panel. The commands *Fault Recording and Swing Recording* are available under the *Records* menu.

> A swing record can take a couple of minutes to produce due to the long post-trigger time.

## Record Duration and Extension

The length of each record is determined by the Record Length setting. Fault record lengths can be set between 0.2 and 2.0 seconds; swing record lengths can be set between 60 and 120 seconds. Pre-trigger times can be set between 0.1 s and 0.5 seconds for fault records and are fixed at 30 seconds for swing records. They are included as part of the normal record length.

The relay automatically extends a record as required to capture consecutive triggers that are close together. If a trigger occurs while a recording is in progress, the record is extended to include the full post-trigger time of subsequent triggers, up to a maximum length — 4.0 seconds for fault records; 180 seconds for swing records. If a trigger occurs before the end of a record caused by a previous trigger, but too late to allow sufficient post-trigger time in a maximum extended record, a new overlapping record is created.

The normal record lengths settings are accessible under the *Recording* heading of the relay settings, and can be set from either the Relay Control Panel or the *Offliner* Settings software.

## Record Storage

The relay compresses records on the fly, achieving a typical lossless compression rate of 4:1. As a result, the relay can store up to 150 seconds of fault recordings and up to 300 minutes of swing recordings in non-volatile storage. If the storage is full, new records automatically overwrite the oldest, ensuring that the recording function is always available.

## Record Retrieval and Deletion

A listing of stored records is available through the Relay Control Panel under the Records>List menu. The listing transfer records to a connected PC and deletes them from storage.

Example:

BPRO-4000-010306-04-2010-05-15 13.17.16.000(Fault)

Records are named by combining the Unit ID setting with the date and time of the initiating record trigger. The record list shows the record type (fault).

To delete a record from storage, use the up/down cursor keys to select the record, then select *D*. The user can also do group deleting and group transferring.

To select multiple records:

1. Select a record.
1. Press the space bar, a asterisk appears to the left of the record to indicate it is selected.
2. Continue selecting and pressing the space bar until all desired records are selected.
3. Select *D*. A message asks Delete all selected files?. Select *Y* for Yes and the files are deleted.

To transfer a record to the PC, use the up/down cursor keys to select the record, then select *r*. The record is automatically transferred to the PC using the PC terminal program's z-modem file transfer protocol. The record is placed in the terminal program's default to receive the directory which was set before transfer to. (e.g. HyperTerminal's default receive directory is set through the its Transfer menu). When transferred, the record name remains unchanged and the file extension indicates the record type: ".bpr" for transient.

When the transfer has taken place, the user can delete the record or leave a copy on the relay.

# 4.2 Logging Functions

## Event Log

The relay maintain a log of events in a 250 entry circular log. Each entry contains the time of the event plus an event description.

Logged events include trips, alarms, external inputs assertions plus internal events such as setting changes. Phase information is included in event messages where appropriate. For example, the event log entry for a device trip might be:

B-PRO-2011- 11- 23-03:34:19.960: 87B-1 Trip on ABC

The event log can be viewed in 2 ways:

**Table 4.16: Event Log**

| | |
|---|---|
| Front Panel | The front panel display shows events in abbreviated form (Trip and Alarm events only). |
| Record Control Panel | The full event log is available through the Event Log menu of the Record Control Panel. |
| SCADA | The protocols included in the relay allow all the SCADA master access to the event data from the relay (Trip and Alarm events only). |

> This display is a snapshot of the event list which must be manually refreshed to display new events that occur while the display is up.

There is a list of Event Messages, for details see “Event Messages” in Appendix D.

# 5 Data Communications

## 5.1 Introduction

Section 5 deals with data communications with the relay. First, the SCADA protocol is discussed, and it is then followed by the new IEC 61850 communication standard.

The SCADA protocol deals with the Modbus and DNP (Distributed Network Protocol) protocols. The SCADA configuration and its settings are described. The parameters for SCADA communications are defined using B-PRO 4000 Offliner software. Finally, details on how to monitor SCADA communications are given for maintenance and trouble shooting of the relay.

## 5.2 SCADA Protocol

### Modbus Protocol

The relay supports either a Modbus RTU or Modbus ASCII SCADA connection. Modbus is available exclusively via a direct serial link.

Serial Modbus communications can be utilized exclusively via serial Comm Port 123. Comm Port 123 is an RS232 DCE DB9F port located on the back of the relay. An external RS-232 to RS-485 converter can be used to connect the relay to an RS-485 network. For details on connecting to serial Comm Port 123 see “Communicating with the Relay Intelligent Electronic Device (IED)” on page 2-3 and “Communication Port Details” on page 2-17.

The data points available for Modbus SCADA interface are fixed and are not selectable by the user. Complete details regarding the Modbus protocol emulation and data point lists can be found in “Modbus RTU Communication Protocol” in Appendix E.

### DNP Protocol

The relay supports a DNP3 (Level 2) SCADA connection. DNP3 is available via a direct serial link or an Ethernet LAN connection using either TCP or UDP.

Serial DNP communications can be utilized exclusively via serial Comm Port 123. Comm Port 123 is an RS232 DCE DB9F port located on the back of the relay. An external RS-232 to RS-485 converter can be used to connect the relay to an RS-485 network. For details on connecting to serial Comm Port 123, see “Communicating with the Relay Intelligent Electronic Device (IED)” on page 2-3 and “Communication Port Details” on page 2-17.

Network DNP communications can be utilized via physical LAN Port 119 or Port 120. Port 119 is available as a pair of RJ45 ports, one on the front of the relay and one on the rear. Port 120 is an ST fiber optic port located on the rear of the relay. DNP communications can be used with multiple masters when it is utilized with TCP. For details on connecting to the Ethernet LAN, see “Network Link” on page 2-7.

The data points available for DNP SCADA interface are selectable by the user. Complete details regarding the DNP3 protocol emulation and data point lists can be found in “DNP3 Device Profile” in Appendix F.

## SCADA Configuration and Settings

The parameters for SCADA communications may be defined using B-PRO 4000 Offliner.

If DNP3 LAN/WAN communications were chosen, the relay's network parameters need to be defined. This is done via the Maintenance interface. Note that this effort may already have been completed as part of the steps taken to establish a network maintenance connection to the relay.

1. Establish a TUI session with the relay and log in as **maintenance**. The following screen appears:

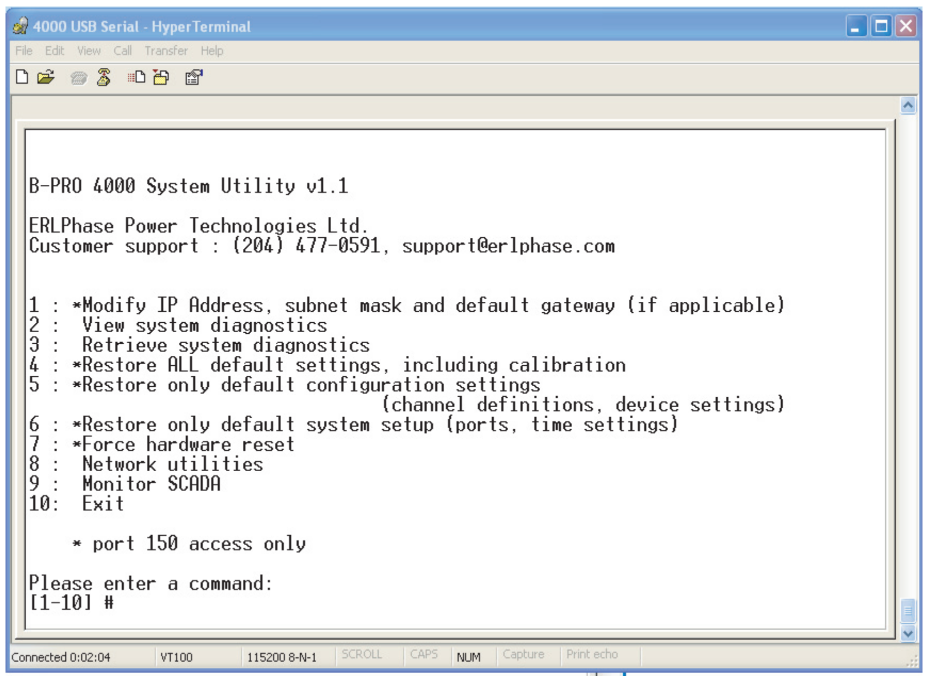



Figure 5.1: B-PRO 4000 System Utility

2. Select the first option by entering the number 1 followed by *Enter*. The following screen appears:

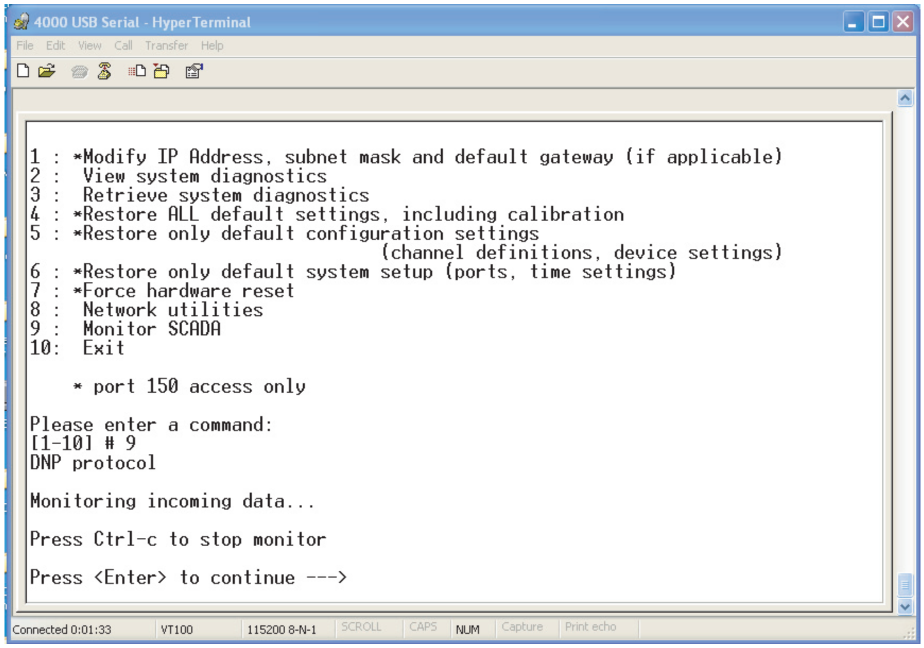



Figure 5.2: Change the network parameters as needed for the particular application

## Offliner SCADA Configuration

Details on using the Offliner software are available in “To Install Software on the Computer” on page -xiii. Details on downloading a completed settings file to the relay are available in “Sending a New Setting File to the Relay” on page 6-6.

Open the Offliner application according to the instructions found in the indicated section and highlight the SCADA Communication selection. The screen appears as follows.

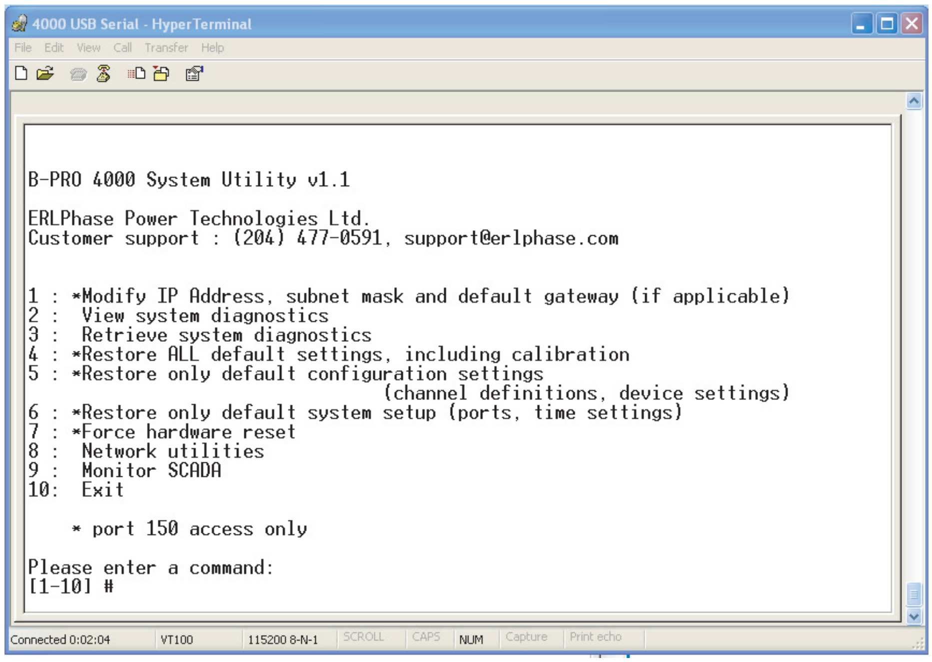



Figure 5.3: SCADA Communications

The configuration of SCADA communication parameters via the Offliner application is very intuitive. Several settings options are progressively visible and available depending on other selections. As noted before, there is no field to configure the number of data and stop bits. These values are fixed as follows:

- Modbus Serial - 7 data bits, 1 stop bit
- DNP Serial - 8 data bits, 1 stop bit

## Monitoring SCADA Communications

The ability to monitor SCADA communications directly can be a valuable commissioning and troubleshooting tool. It assists in resolving SCADA communication difficulties such as incompatible baud rate or addressing. The utility are accessed through the .

1. Establish a TUI session with the relay and log in as **maintenance**.
2. Select the option 9 by entering the number 9 followed by *Enter*. The following screen appears:

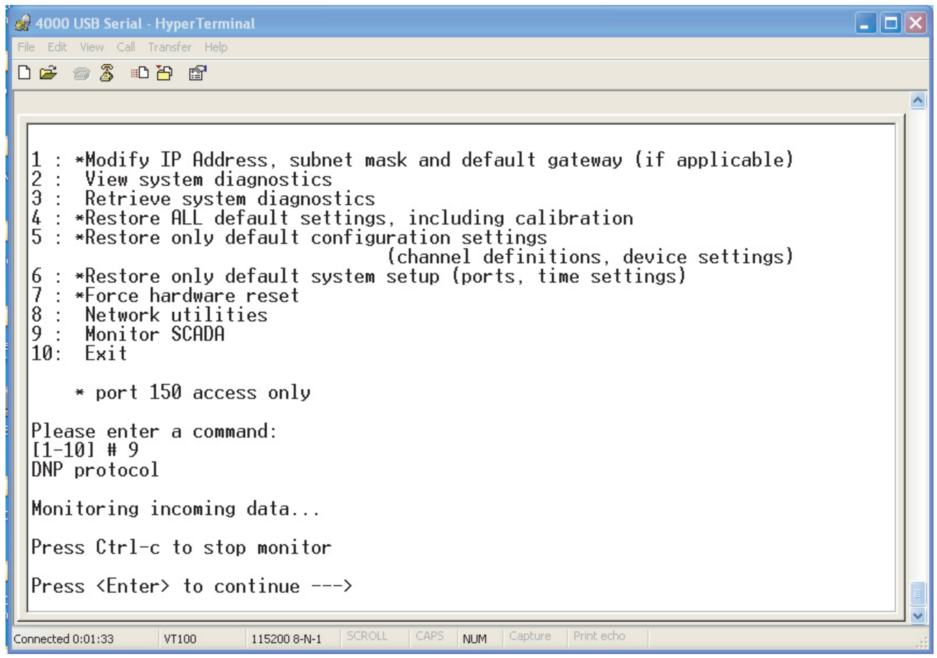



Figure 5.4: Login Screen

3. Pressing the *Enter* key results in all SCADA communications characters to be displayed as hexadecimal characters. Individual exchanges are separated by an asterisk as the following sample illustrates:

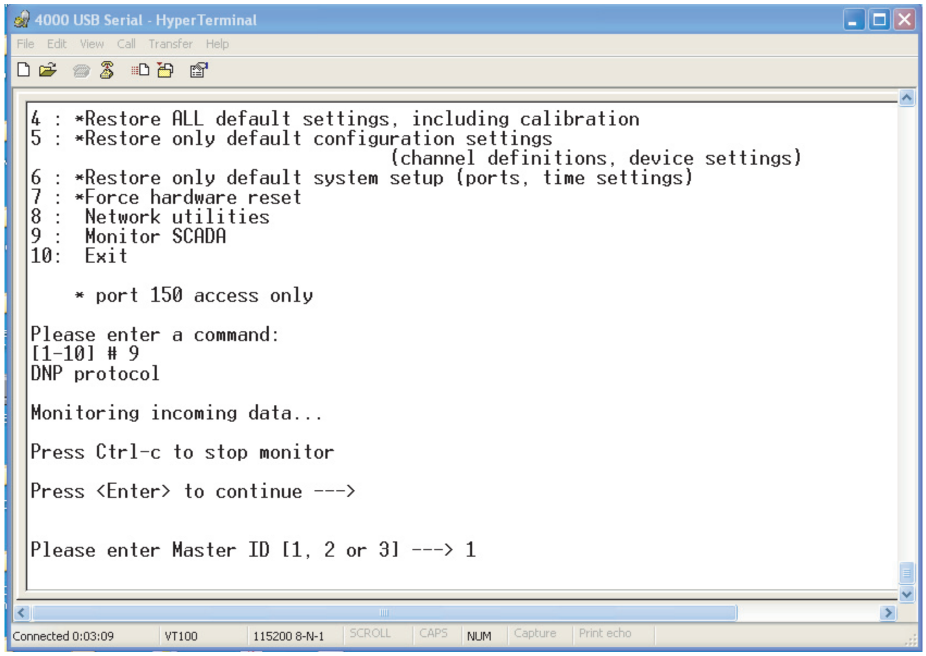



Figure 5.5:

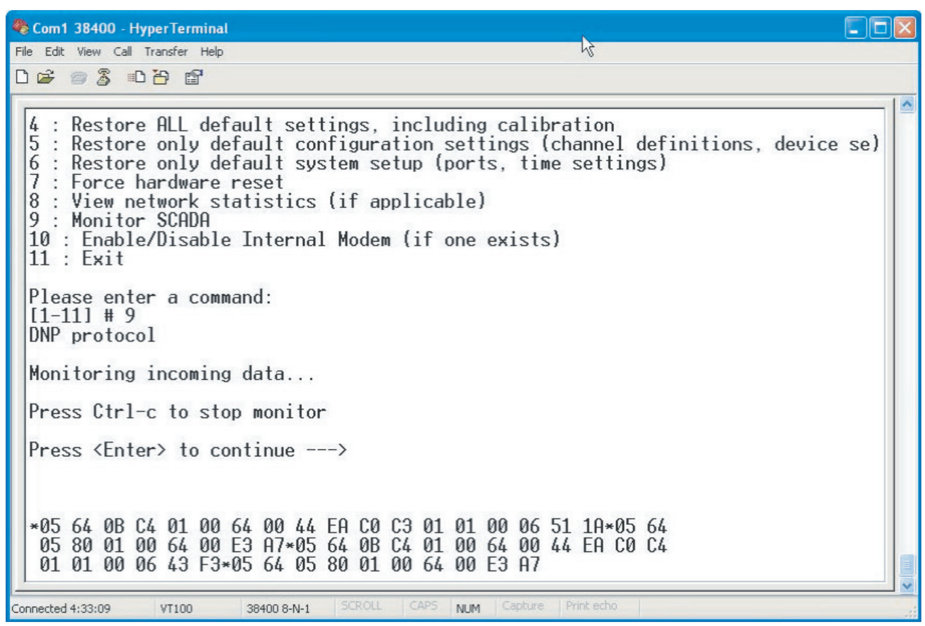



Figure 5.6: Hyperterminal

4. Press *Ctrl-C* to end the monitor session.

# 5.3 IEC61850 Communication

## The IEC 61850 standard

The Smart Grid is transforming the electrical power industry by using digital technology to deliver electricity in a more intelligent, efficient and controlled way. Embedded control and communication devices are central to this transformation by adding intelligent automation to electrical networks.

The IEC 61850 standard defines a new protocol that permits substation equipment to communicate with each other. Like many other well-known manufacturers, ERLPhase Power Technologies is dedicated to using IEC 61850-based devices that can be used as part of an open and versatile communications network for substation automation.

The IEC 61850 defines an Ethernet-based protocol used in substations for data communication. Substations implement a number of controllers for protection, measurement, detection, alarms, and monitoring. System implementation is often slowed down by the fact that the controllers produced by different manufacturers are incompatible, since they do not support the same communication protocols. The problems associated with this incompatibility are quite serious, and result in increased costs for protocol integration and system maintenance.

## Implementation Details

Implementation includes the following documents:

1. Protocol Implementation Conformance Statement
2. Model Implementation Conformance Statement
3. Tissues Conformance Statement

All configurable IEC61850 parameters are available via the Maintenance interface. Note that this effort may already have been completed as part of the steps taken to establish a network maintenance connection to the relay.

1. Establish a TUI session with the relay and login as **maintenance**. The following screen appears.

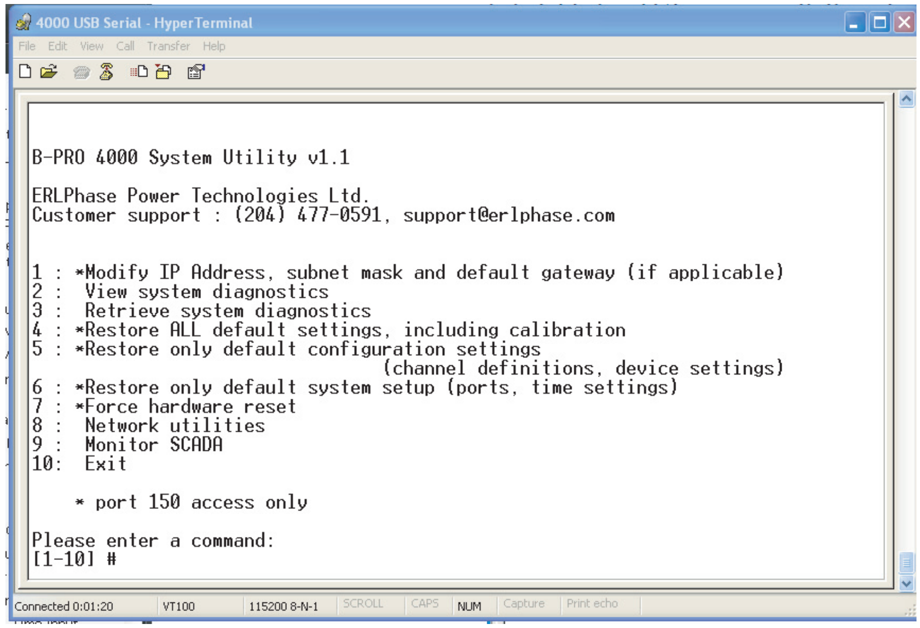



Figure 5.7: Maintenance Interface

2. Select the first option by entering the number **1** followed by *Enter*. The following screen appears:

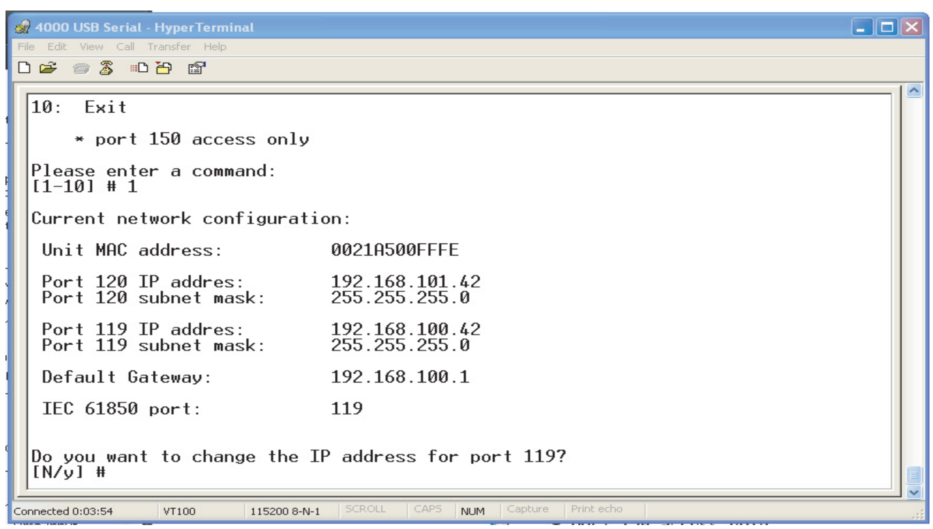



Figure 5.8: Change the network parameters as needed for the particular application

Note that unit's IP address can be used on the IEC61850 client side for unique unit identification instead of a physical device "PD Name". The publisher configuration is fixed and defined in the ICD file and available for reading to any

IEC61850 client. Subscriber functionality is also fixed and supported for the Virtual Inputs only.

# 6 Offliner Settings Software

## 6.1 Introduction

This section deals with the Offliner Settings software. The Offliner Settings software is used to create relay settings on a personal computer. Offliner provides an easy way to view and manipulate settings. Offliner supports all firmware versions and has the capability to convert older setting versions into newer ones.

In this section, first, the Offliner features are presented. The menu and tool bar are discussed and this is followed by a description of the Graphing and Protection functions.

Next, the Offliner features for handling backward compatibility with previous software versions is described. Also described are methods of converting a Settings File, sending a new Settings File to the relay and creating a Settings File from an older version of the software.

Next, the RecordBase View and RecordGraph software to analyze the records from a relay are described.

This is followed by a lengthy description of the main branches from the Tree View. This section provides all information for Identification, System Parameters, SCADA Communication, DNP Configuration, SCADA Settings summary, Record Length, ProLogic, Group Logic, Output Matrix and Settings summary.

Finally, a description of how the settings on the relay can be viewed through the RecordBase View analysis software is provided.

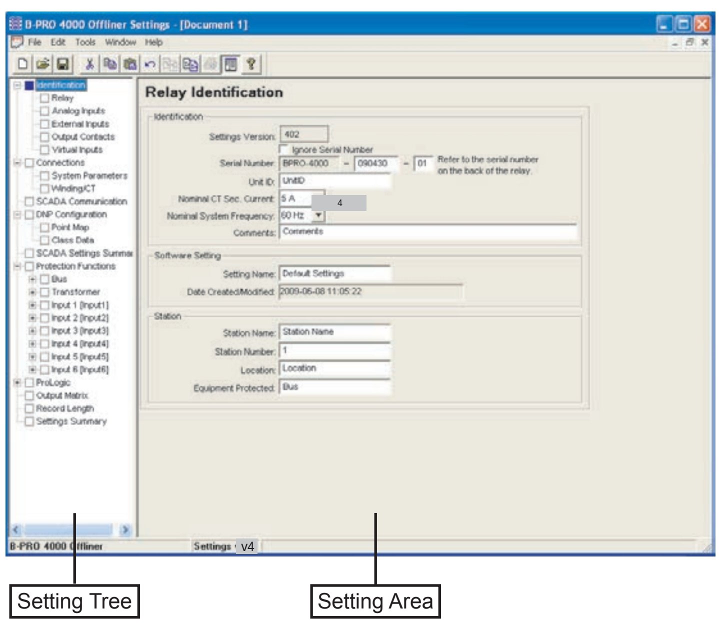



Figure 6.1: Opening Screen

# 6.2 Offliner Features

## Menu and Toolbar

The Offliner software includes the following menu and system tool bar. for details see Figure 6.2: Top Tool Bar on page 2 describes the details.

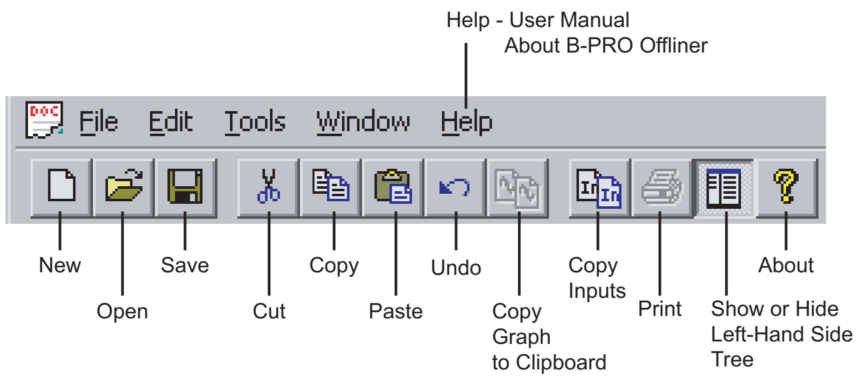



Figure 6.2: Top Tool Bar

| Table 6.1: Windows Menu | | |
|---|---|---|
| Windows Menu | **Sub Menu** | **Comment** |
| **Document Menu (Icon)** | Restore | Restores active window to previous size |
| | Move | Allows user to move active window |
| | Size | Allows user to resize active window |
| | Minimize | Makes the active window as small as possible |
| | Maximize | Makes the active window as large as possible |
| | Close | Closes the active *Offliner* setting document |
| | Next | Switches to the next open *Offliner* setting file, if more than setting file is being edited |

| Table 6.1: Windows Menu | | |
|---|---|---|
| **File Menu** | New | Opens up a default setting file of the most recent setting version |
| | Open | Open an existing setting file |
| | Close | Closes the active *Offliner* setting document |
| | Save | Saves the active setting file |
| | Save As | Saves the active setting file with a new name or location |
| | Convert to Newer | Convert an older setting version to a newer version. |
| | Print | Prints graphs or setting summary depending on active screen |
| | Print Preview | Provides a print preview of the setting summary |
| | Print Setup | Changes printers or print options |
| | Recent File | The six most recently accessed setting files |
| | Exit | Quits the program |
| **Edit Menu** | Undo | Undo last action |
| | Cut | Cut the selection |
| | Copy | Copy the selection |
| | Paste | Insert clipboard contents |
| | Copy Graph | Copy the graph for the active screen to the clipboard |
| | Copy Inputs | Brings up the Copy Inputs dialog box |
| **Tools** | Options | Displays the Options Dialog Box |
| **Window** | Cascade | Cascades all open windows |
| | Tile | Tiles all open windows |
| | Hide/Show Tree | If this option is checked then the LHS Tree view will be hidden |
| | 1-9, More Windows | Allows access to all open *Offliner* setting files. The active document will have a check beside it |
| **Help** | User Manual | Displays the user manual |
| | About *Offliner* | Displays the *Offliner* version |
| **Toolbar** | | |
| New | Create a new document. | Create a new document of the most recent setting version |
| Open | Open an existing document. | Open an existing document |

| Table 6.1: Windows Menu | | |
|---|---|---|
| Save | Save the active document. | Save the active document |
| Cut | Cut the selection. | Cut selection |
| Copy | Copy the selection. | Copy the selection |
| Paste | Insert clipboard contents. | Insert clipboard contents |
| Undo | Copy graph to clipboard. | Undo last action |
| Copy Graph | | Copy the graph for the active screen to the clipboard |
| Copy Inputs | Copy inputs. | Brings up the Copy Inputs dialog box |
| Show/Hide LHS Tree | | If this option is checked then the LHS Tree view will be hidden |
| Print | Print active document. | Prints Graphs or the setting summary, depending on which seen is selected |
| About | Display program information. | Displays the *Offliner* version |

# 6.3 Offliner Keyboard Shortcuts

The following table lists the keyboard shortcuts that Offliner provides.

| Table 6.2: Keyboard Shortcuts | |
|---|---|
| Ctrl+N | Opens up a default setting file of the most recent setting version |
| Ctrl+O | Open an existing setting file |
| Ctrl+S | Saves the active setting file |
| Ctrl+Z | Undo |
| Ctrl+X | Cut |
| Ctrl+C | Copy |
| Ctrl+V | Paste |
| Ctrl+F4 | Closes the active Offliner setting document |
| Ctrl+F6 | Switches to the next open Offliner setting file, if more than one setting file is being edited |
| F6 | Toggles between the LHS Tree view and HRS screen |
| F10, Alt | Enables menu keyboard short-cuts |
| F1 | Displays the user manual |

## Protection Functions

### Grid On/Grid Off

The graph can be viewed with the grid on or off by clicking the Grid On or Grid Off button.

### Refresh

This button will manually refresh the graph if it has been zoomed.

### Print Graph

To print a particular graph, click the *Print Graph* button.

### Zoom on Graphs

Graphs can be zoomed to bring portions of the traces into clearer display. Left-click on any graph and drag to form a small box around the graph area. When the user releases the mouse, the trace assumes a new zoom position determined by the area of the zoom coordinates.

To undo the zoom on the graph, click the *Refresh* button.

### Displaying Co-ordinates

At any time the user may right-click on the graph to display the co-ordinates of the point the user selected.

# 6.4 Handling Backward Compatibility

*Offliner* Settings displays the version number in the second pane on the bottom status bar. The settings version is a whole number (v1, v2, v3, v4, etc.).

The *Offliner* Settings is backward compatible; open and edit older settings files and convert older settings files to a newer version. *Offliner* settings handles forward conversion only — it converts an older setting file to a newer setting file.

## Converting a Settings File

1. Open the setting file to convert.
2. In the *File* menu, select *Convert to...* and then select the *version x* (where x is the newer version). A dialog box pops up prompting *Offliner* for a new file name. Use either the same file name or enter a new file name. The conversion process inserts default values for any newly added devices in the new setting file. When the conversion is complete, *Offliner* Settings displays the new file.

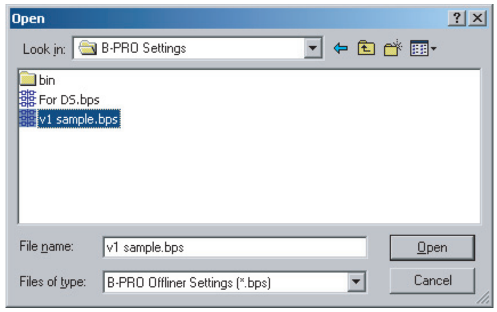



Figure 6.3: Converting Setting Files

## Sending a New Setting File to the Relay

1. Make sure the settings version and the serial number of the relay in the setting file match. The relay will reject the setting file if either the serial number or the settings version do not match.

> A “serial number discrepancy” message may appear. This is to ensure that the user is aware of the exact relay in which settings are to be loaded. If this happens, check the relay serial number using the ID menu item. Type this serial number into the B-PRO Serial No. box in the Identification tab display area of *Offliner* Settings. Alternately the user may check the Ignore Serial Number check box to bypass serial number supervision.

2. Check the serial number and the settings version of the relay. The Device Serial Number and Required Settings Version on the Identification screen indicate the serial number and the settings version of the relay.

## Creating a Setting File from an Older Version

1. *Offliner* Settings displays a default setting file on start up showing the settings version in the bottom status bar. As an example B-PRO Offliner is shipped with a set of default sample files of older settings versions. These sample files are “v1 sample.lps”, “v2 sample.lps”, “v3 sample.lps”, etc. Each sample file contains default values of an older settings version. For a new installation these sample files are placed in the default directory C:\Program Files\ERLPhase\B-PRO Offliner Settings, or the user can choose the path during the *Offliner* software installation. If an older version of B-PRO Offliner was previously installed on the PC, then the default directory may be C:\Program Files\APT\B-PRO Offliner Settings.
2. Open a sample file of the desired version. Use *File/Save As* to save the sample file to a new file name. Then edit the setting file and the serial number, save it and load it into the relay.

# 6.5 RecordBase View Software

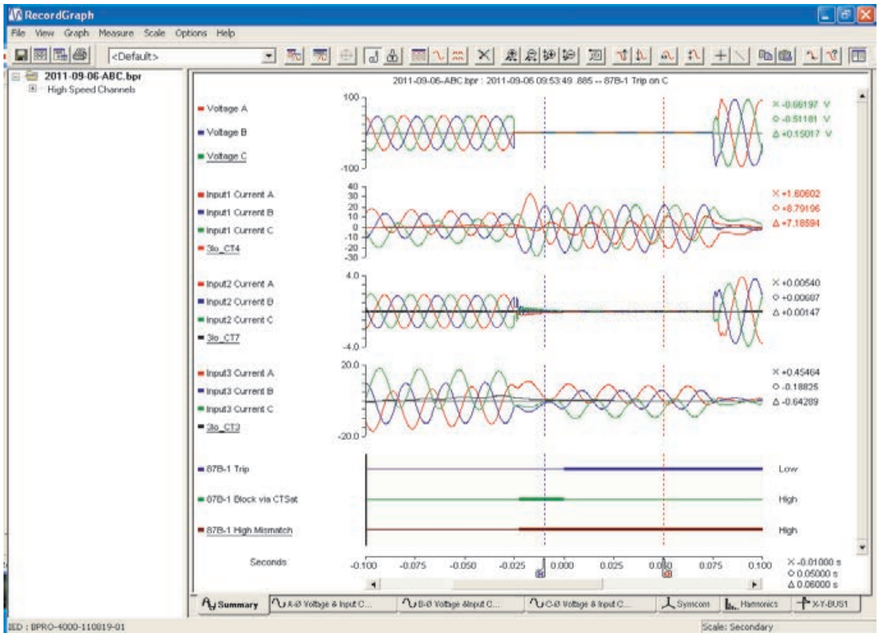



Figure 6.4: RecordGraph

Use RecordBase View and RecordGraph to analyze the records from a relay.

1. Set the receive directory on the terminal program to point to a convenient directory on the PC’s hard disk or network. For example with HyperTerminal, select *Transfer>Receive File* to set the receive directory.
2. Select one or more records on the relay using the *List* function in the ’s *Records* menu.
3. Initiate transfer of the selected records by selecting *R* on the keyboard.
4. Start the RecordBase View program and use the *File>Open* menu command to open the downloaded record files located in the receive directory specified in step 1.

For further instructions refer to the RecordBase View Manual at the back of the printed version of this manual.

# 6.6 Main Branches from the Tree View

This section will describe the tree view, which provides access to the various setting screens. This section will not describe individual settings, but will provide a general description of where to find the individual settings. For a detailed description of the individual settings, see Chapter 4.

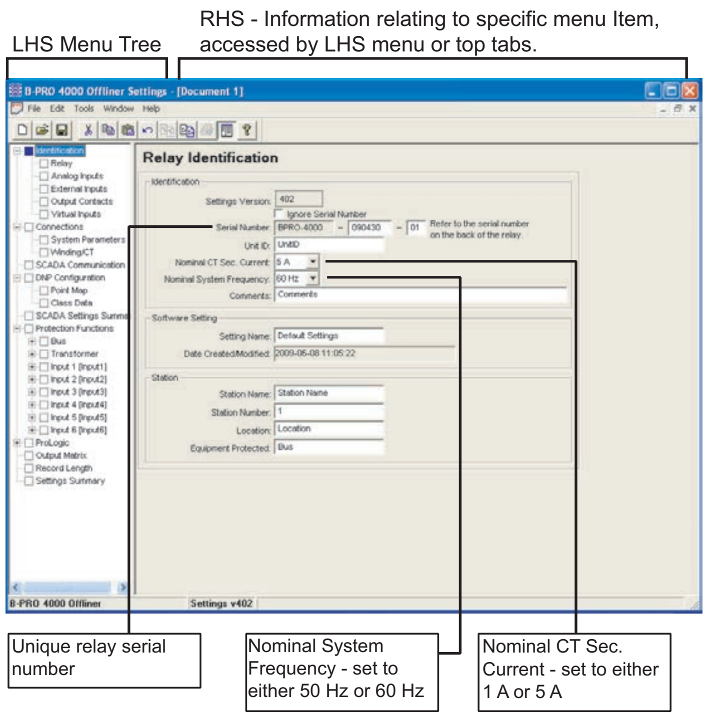



Figure 6.5: Relay Identification

In the LHS Menu Tree there are a series of menu headings that may have sub menus associated with them. for details see Figure 6.5: Relay Identification on page 8 shows the LHS tree view. Clicking on an item in the left hand side tree view will display its corresponding menu in the RHS view. Similarly, the user can use the arrow keys to scroll through the menu tree.

These menus are where the settings for the backup feeder protection are located. Inputs 1-6 are identical and include menus for 50LS, 50BF, 50/51/67, 50N/51N/67 and 46-50/46-51/67 settings.

## Identification

The first screen presents all the menu items in the left menu tree. Access the menu items by clicking the tabs at the top of the screen or the item on the left menu tree.

| Table 6.3: Identification | |
|---|---|
| **Identification** | |
| Settings Version | Indicates the settings version number, fixed. |
| Ignore Serial Number | Bypass serial number check, if enabled. |
| Serial Number | Available at back of each relay. |
| Unit ID | User-defined up to 20 characters. |
| Nominal CT Format | 5 A or 1 A |
| Nominal System Frequency | 60 Hz or 50 Hz |
| Comments | User-defined up to 20 characters. |
| **Setting Software** | |
| Setting Name | User-defined up to 20 characters. |
| Date Created/Modified | Indicates the last time settings were entered. |
| **Station** | |
| Station Name | User-defined up to 20 characters. |
| Station Number | User-defined up to 20 characters. |
| Location | User-defined up to 20 characters. |
| Equipment Protected | User-defined up to 20 characters. |

Important Note

Nominal CT Secondary Current can be set to either 1 A or 5 A. Nominal System Frequency can be set to either 50 Hz or 60 Hz. Ensure setting selection matches that of target the relay.

The serial number of the relay must match the one in the setting file, or the setting will be rejected by the relay. This feature ensures that the correct setting file is applied to the right relay.

Choose to ignore the serial number enforcement in the identification screen by checking the *Ignore Serial Number* check box. The relay only checks for proper relay type and setting version if the ignore serial number has been chosen, requires relay firmware version 1.0 or greater.

## Analog Input

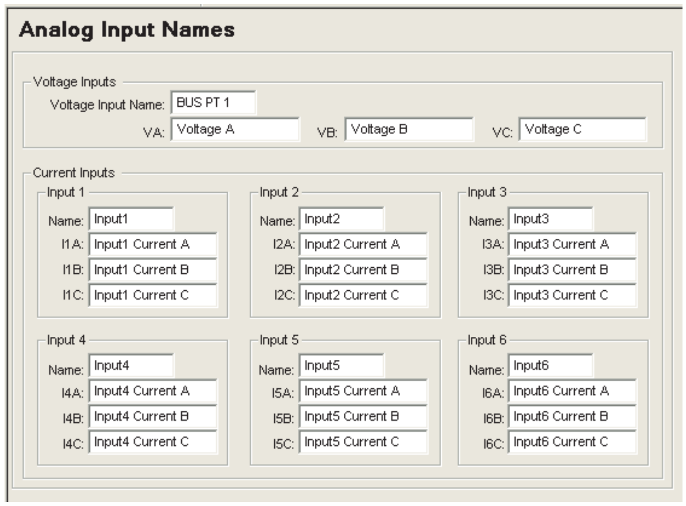



Figure 6.6: Analog Input Names

Analog Input Names screen identifies all the ac voltage and current inputs to the relay. These names appear in any fault disturbance records the relay produces.

**Table 6.4: Analog Input**

| | |
|---|---|
| Main Voltage | LVA, LVB, LVC |
| Main Current | LIA, LIB, LIC |
| Aux. Voltage | BVA, BVB, BVC |
| Aux. Current | IA2, IB2, IC2 |
| Current | IA3, IB3, IC3, IA4, IB4, IC4 |

### External Input

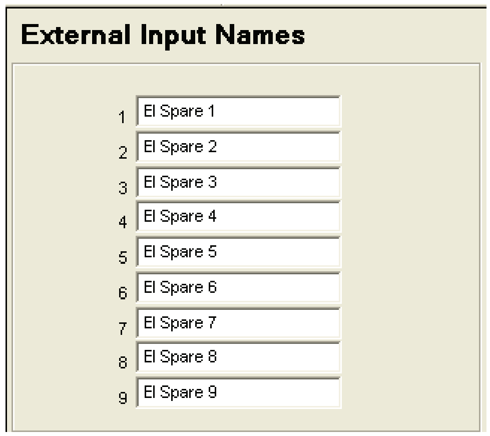



Figure 6.7: External Input Names

External Input Names screen allows the user to define meaningful names for 20 external digital inputs.

| Table 6.5: External Input Names | |
|---|---|
| 1 to 20 | User-defined |

### Output Contact

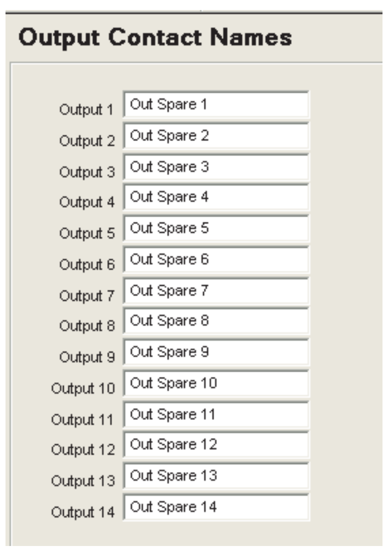



Figure 6.8: Output Contact Names

The Output Contacts are also identified during the setting procedure using meaningful names.

| Table 6.6: Output Contacts Names | |
|---|---|
| 1 to 14 | User-defined |

### Virtual Inputs

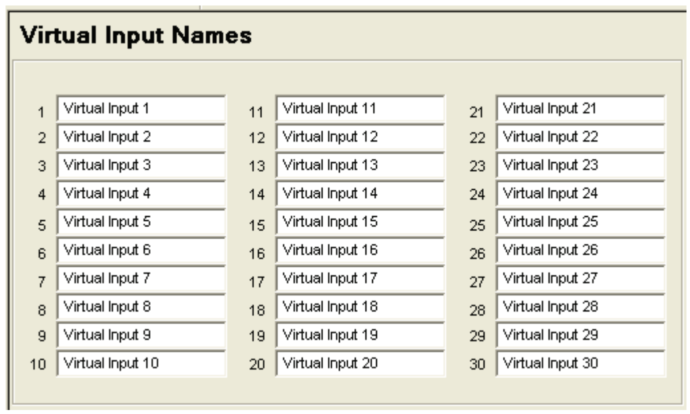



Figure 6.9: Virtual Input Names

| Table 6.7: Virtual Inputs | |
|---|---|
| Virtual Inputs 1 to 30 | User-defined |

The relay can control its internal functions and connected devices both locally and remotely. Thirty general purpose logic points are accessible via DNP3 and the TUI. The 30 virtual inputs are individually controlled and include a set, reset and pulse function. The latch state is retained during setting changes and relay power down conditions. The 30 virtual inputs conform to DNP3 standards. Use the DNP3 functions such as SBO (select before operate), Direct Operate, or Direct Operate with no acknowledge to control virtual inputs.

Use virtual inputs to:

- Control circuit breakers
- Enable or disable reclosing
- Enable or disable under-frequency load shedding
- Provide interlocking between local/remote supervisory control

## Connections

### Sub Menus

System Parameters and Winding/CT Connections

These menus contain the settings that are used to define the primary system that is connected to the relay. Settings such as Bus Base MVA, Nominal Voltage Level are made in the System Parameters screen. The Windings/CT screen contains settings such as differential zone, CT ratio settings, transformer settings and digital control.

### System Parameters

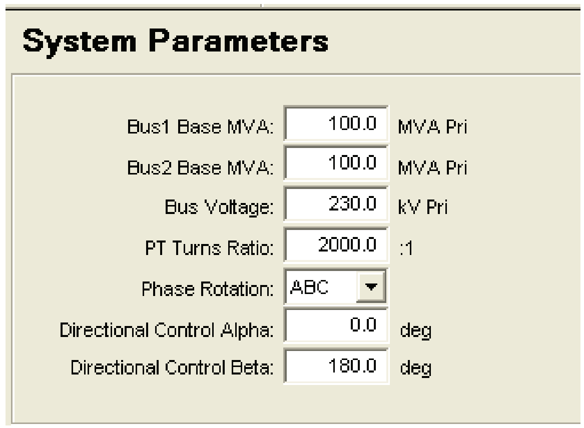



Figure 6.10: System Parameters

| Table 6.8: System Parameters | |
|---|---|
| Bus1 Base MVA | 100.0 MVA Pri |
| Bus 2 Base MVA | 100.0 MVA Pri |
| Bus Voltage | 230.0kV Pri |
| PT Turns Ratio | 2000.0:1 |
| Phase Rotation | ABC or ACB |
| Directional Control Alpha | 0.0 degrees |
| Directional Control Beta | 180.0 degrees |

## Winding/CT Connections

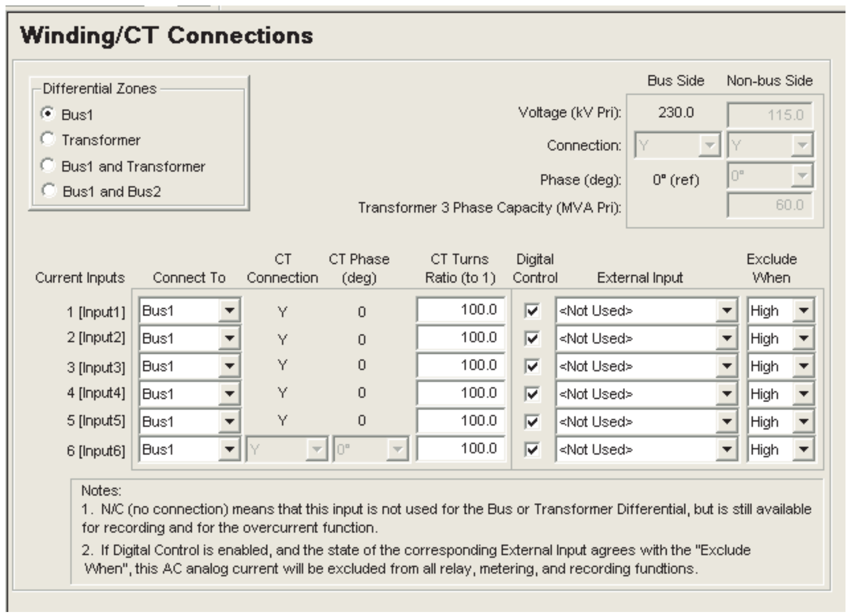



Figure 6.11: Winding/CT Connections

## SCADA Communication

The relay has configurable SCADA communication parameters for both Serial (Port 123) and Ethernet (TCP and UDP). For DNP3 Level 2 (TCP) up to three independent Masters are supported.

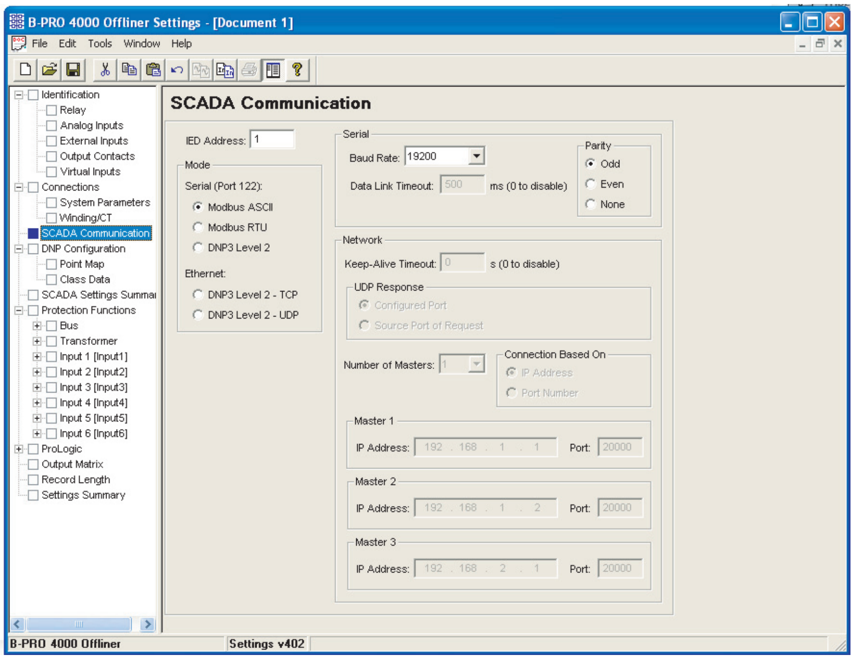


Figure 6.12: SCADA Communications

# Protection Summary

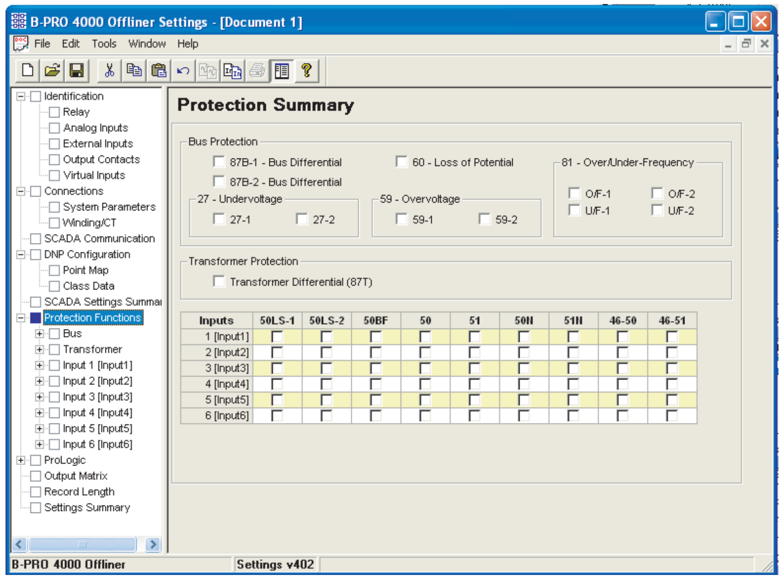



Figure 6.13: Protection Summary

### Sub Menus

Bus, Transformer, Inputs 1-6

These menus are used to make the individual settings for the various protection devices provided by the relay. Each of the sub menus above can be broken further into sub menus for the different protective zones available. Note that selecting the Protection Functions item in the LHS tree view will display the Protection Summary screen in the RHS Tree view. This screen will display the enabled/disabled status of all devices in the relay, and will also allow these devices to be enabled/disabled.

### Bus Sub Menu

This sub menu contains the settings for the devices that are in the Bus Zone. These functions are the 87B-1, 87B-2 and the voltage devices, 27, 59, 60, and 81.

### Transformer Sub Menu

This sub menu contains only one item, the 87T settings. This is the only device that is provided for the transformer protection zone.

### Inputs 1-6 Sub Menus

## Bus Protection

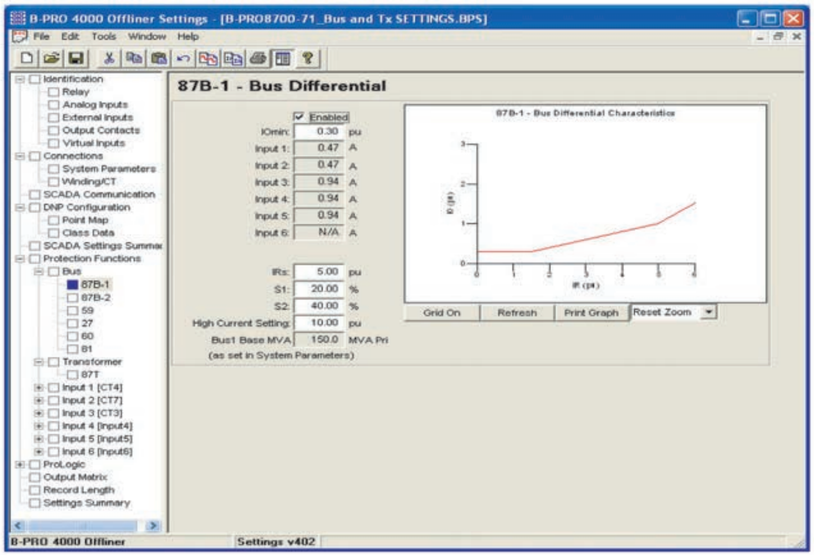



Figure 6.14: 87B-1 Bus Protection

## Transformer Protection

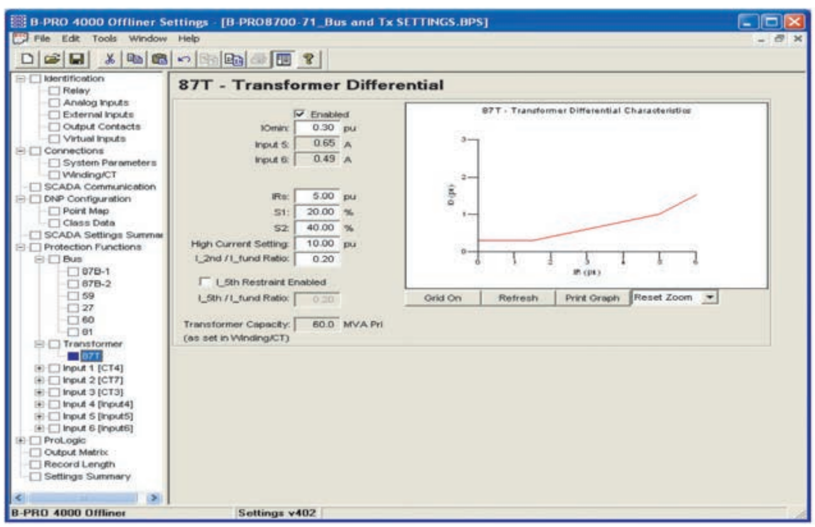



Figure 6.15: 87T - Transformer Differential

# ProLogic

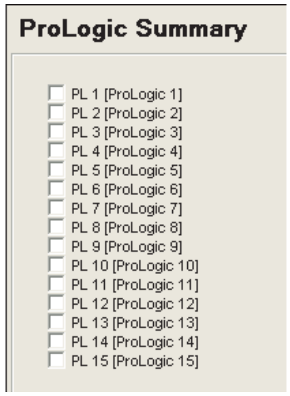



Figure 6.16: ProLogic

### Sub Menus

ProLogic 1 - ProLogic 15

This where each ProLogic statement that is provided by the relay can be defined. There are 15 ProLogic statements available in the relay, so there are 15 screens. Similar to the Protection Functions menu, selecting ProLogic in the LHS tree view will bring up the ProLogic Summary screen, which displays the enabled/disabled status of all ProLogic. The user can also enable or disable any ProLogic from this screen. This unique ProLogic name is also displayed on this screen, in brackets next to the generic ProLogic name.

## Output Matrix

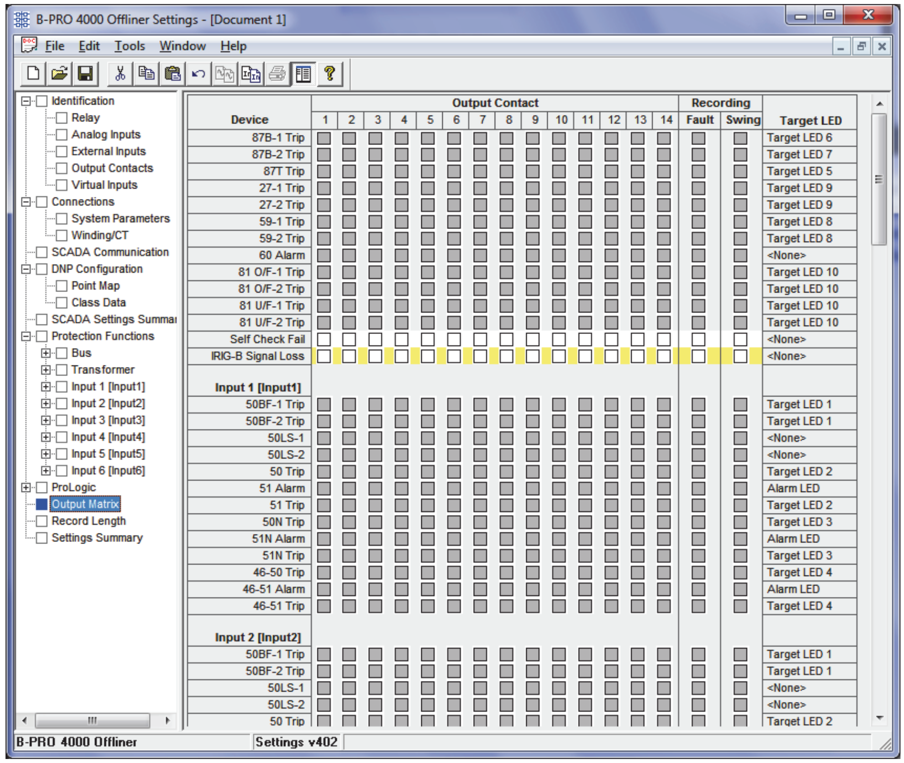



Figure 6.17: Output Matrix

This is where the relay's protection devices, external inputs, virtual inputs, and ProLogics can be configured to close output contact (s) or trigger recordings.

## Record Length

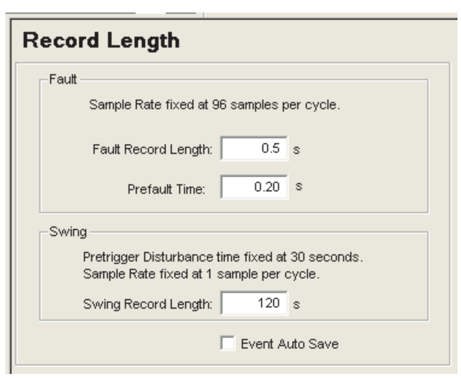



Figure 6.18: Record Length

This screen contains the settings for setting the length of fault and swing recording.

## Settings Summary

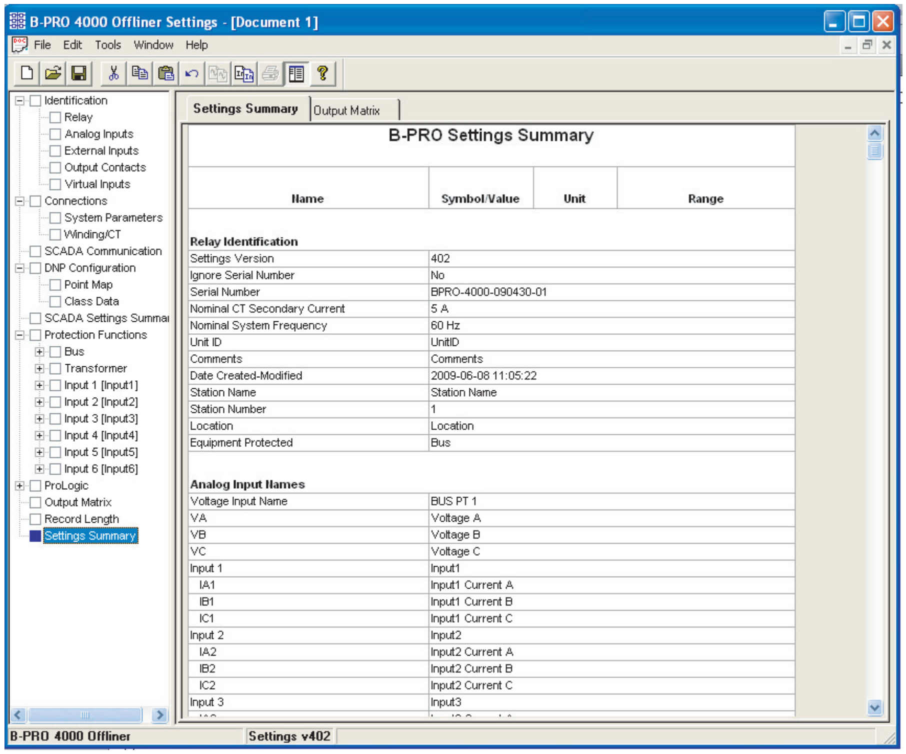



Figure 6.19: Settings Summary

This menu provides a read-only list of all the relay's settings. The setting names, values, units and ranges are displayed. For the protection devices, the user can use the "display and print only enabled protection devices" option from the Tools menu to shorten the summary such that if a device is not enabled, its settings will be hidden, except that the enabled setting will be displayed. This is convenient if the user is not using all of the available devices.

# 6.7 Settings From a Record

The settings on the relay at the time of a recording are included in every record and can be viewed through the RecordBase View analysis software. While viewing a recording in RecordBase View, select the *View Setting* button to display the settings. RecordBase View will automatically launch B-PRO Offliner to display the settings in summary form.

The setting summary is read-only. To edit the setting file associated with the summary, the user must use *File/Save As* to save the summary to a file. Then close the summary screen and open the setting file for editing.

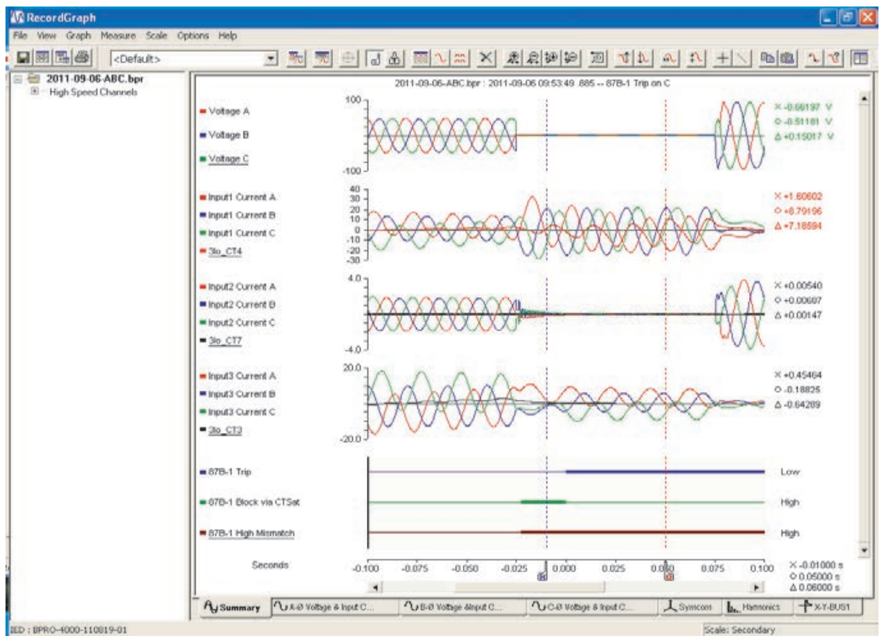



Figure 6.20: View Setting Summary in RecordBase View

# 7. Acceptance/Protection Function Test Guide

## 7.1 Introduction

The acceptance test section is a guide for testing any and all protection elements in the relay. These tests should be performed upon first delivery of the relay, prior to applying in-service settings. Once in-service settings are applied, ERLPhase recommends that the user test enabled functions to ensure the designed application is fulfilled.

This section deals with the Acceptance Testing and the B-PRO Acceptance Test Procedure.

First, the acceptance testing describes the test equipment requirements, calibration methods, testing the external inputs and testing the output relay contacts.

Next, a step-by-step test procedure for testing all the relay devices are outlined.

## 7.2 Acceptance Testing

ERLPhase relays are fully tested before leaving the factory. A visual inspection of the relay and its packaging is recommended on receipt to ensure the relay was not damaged during shipping.

> The electronics in the relay contain static sensitive devices and are not user-serviceable. If the front of the relay is opened for any reason exposing the electronics, take extreme care to ensure that the user and the relay are solidly grounded.

Generally an analog metering check, as well as testing the I/O (External Inputs and Output Contacts) is sufficient to ensure the functionality of the relay. Further tests can be performed on delivery and acceptance of the purchaser's option according to the published relay specifications in "IED Settings and Ranges" in Appendix B.

### Test Equipment Requirements

- 3 ac voltage sources (variable frequency capability)
- 3 ac current sources
- 1 ohmmeter
- 1 – 125 Vdc test supply

| |
|---|
| Set nominal CT secondary current to either 5 A or 1 A, and nominal system frequency to either 60 Hz or 50 Hz. This example uses 5 A/ 60 Hz. |

## Calibration

The relay is calibrated before it leaves the factory; but if component changes are made within the relay, the user may need to do a re-calibration.

| |
|---|
| Before beginning a new calibration, establish the accuracy of the equipment being used. |

To perform a calibration, the user must be logged into the relay using Relay Control Panel. Once you are logged on to the B-PRO relay go to *Utilities* then in Utilities go to the *Analog Input Calibration* tab. The *Calibrate* menu leads the user through every analog input and prompts the user to apply the appropriate quantity.

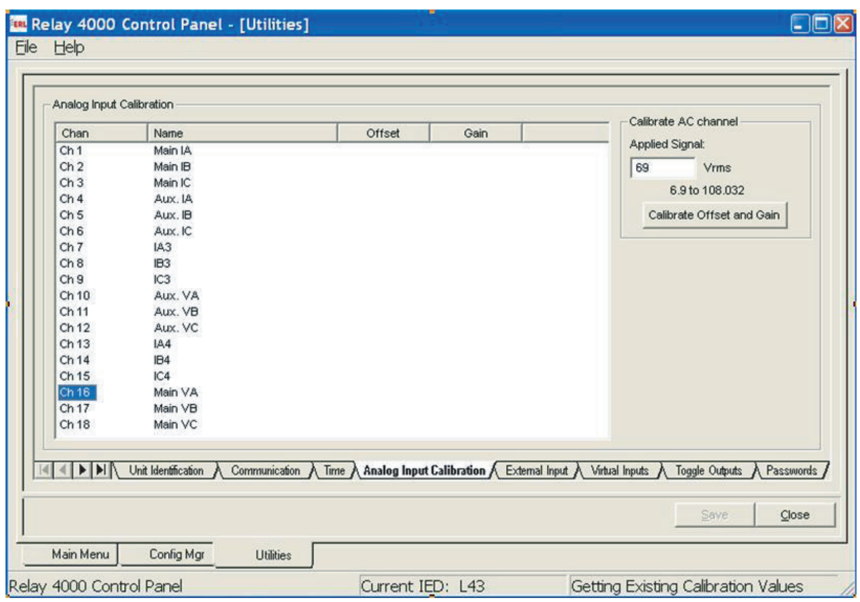



Figure 7.1: Enter actual applied signal level

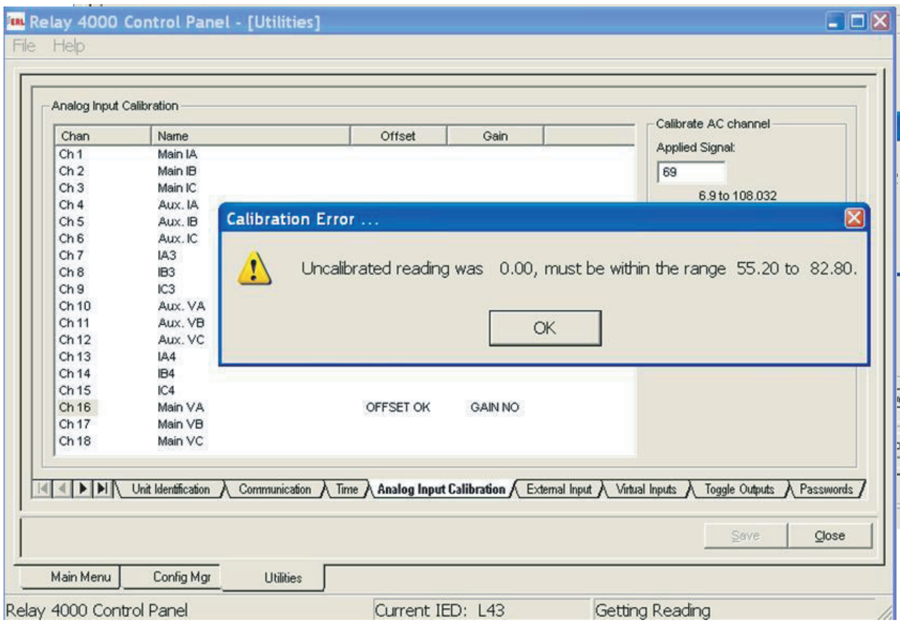



Figure 7.2: Calibration error – out of range

For example, when selecting voltage $V_A$ for calibration, a prompt appears which asks which quantity the relay should try to calibrate. If a 66 V phase-to-neutral quantity is applied to the back $V_A$ terminals, 66.0 V would be indicated as the desired calibration.

In a similar way, the user is prompted to go through all 18 ac analog quantities and provide the information about the injected calibration quantities. The user must have a test source to perform this function. Only the magnitude of the analog input requires calibration, not the angle.

When an analog input channel is calibrated, verify the quantity measured by selecting the Metering menu and the Analog Quantity submenu. $V_A$ of the ac voltage input is used as a reference quantity by the relay. Therefore, if it is absent, there is not a locked, valid relationship among all of the analog quantities.

## Testing the External Inputs

To test the external inputs connect the relay to a laptop in *Relay Control Panel, Service level>Metering Screen/External Tab.* This screen displays the status of the Input and Output Contacts. Placing a voltage of 125 $Vdc_{nominal}$, (150 $V_{maximum}$), to each of the external inputs in turn causes the input to change from Low to High status. These inputs are polarity sensitive and this screen has a 0.5 second update rate.

## Testing the Output Relay Contacts

Test the output relays to verify their integrity by logging on in *Direct connection*, service mode communications, front USB port (115,000 baud), *Utilities Screen/Toggle Outputs Tab*. Put a check in the *Relay in Test Mode*, and select the output contact from the drop down menu and toggle the *Close* or *Open* buttons to operate the output contact. Leaving this tab, each contact status reverts to the open position.

# 7.3 B-PRO Acceptance Test Procedure Outline

## Devices to Test

- 60 LOP for loss of one or two phases, 10 second fixed delay
- 59 AND/OR (two stages, 59-1 & 59-2, each selectable as 3-phase (AND), or single-phase (OR))
- 81O two overfrequency elements, fixed pickup, definite time delay.
- 81U two underfrequency elements, fixed pickup, definite time delay.
- 50N/51N Neutral Overcurrent
- 50/51 phase Overcurrent
- Directional Control Alpha and Beta
- 50BF Breaker Fail
- 46-50/46-51 Negative Sequence Overcurrent
- 87B minimum operate, dual slope, high set, digital control, CT saturation detector
- 87T minimum operate, dual slope, high set (Unrestrained)
- 27 AND/OR (two stages, 27-1 & 27-2, each selectable as 3-phase (AND), or single-phase (OR))

## About the Acceptance Test Setting File

The Acceptance Test Setting File provided by ERLPhase is not necessarily configured to provide a realistic setting example. Its configuration is intended to demonstrate simple test methods for each relay element. Tests are organized in such a way as to prevent interference of one protection element on the next within the relay for ease of testing, without using multiple setting files and minimizing the number of test connection changes. Meanwhile, all contacts in the relay will be tested if all elements of this procedure are tested as written.

## Review the Acceptance Test Setting File

To perform maintenance tests, modify the applicable relay test quantities by going through the calculation processes described in the following procedures (i.e. substitute acceptance test setting values with your actual setting values).

To perform functional tests it may be simpler to use the Acceptance Test Setting File provided by ERLPhase. The file is named BPROaccTestsetting##hz.bps (where ## is for either 50 or 60 for the nominal frequency of the relay.) The Acceptance Test Setting File can be located B-PRO software CD which is inserted in the B-PRO User Manual, or from the www.ERLPhase.com website.

Please see “About the Acceptance Test Setting File” on page 7.-4 for details on the structure and intent of the Acceptance Test Setting File.

## Download Acceptance Test File

Load the Acceptance Test Setting File into the B-PRO relay. Note that this file has “Ignore Serial Number” checked. If this was not done, the exact B-PRO serial number would need to be entered into the file and saved in order for the B-PRO to accept it.

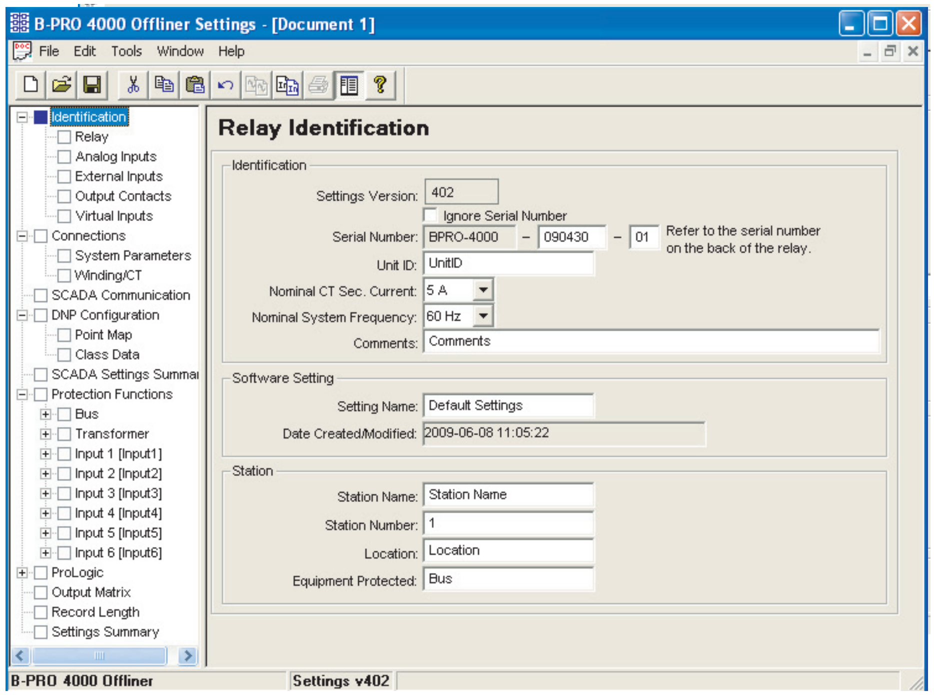



Figure 7.3: Identification Serial Number Screen

## Load the setting file into the B-PRO

Connect to the B-PRO in service or change mode via the B-PRO front RS-232 serial port (Port 1) using your Terminal emulation program (e.g. Hyperterminal). Use VT100 (not VT100J) emulation. Default Baud Rate is 38400.

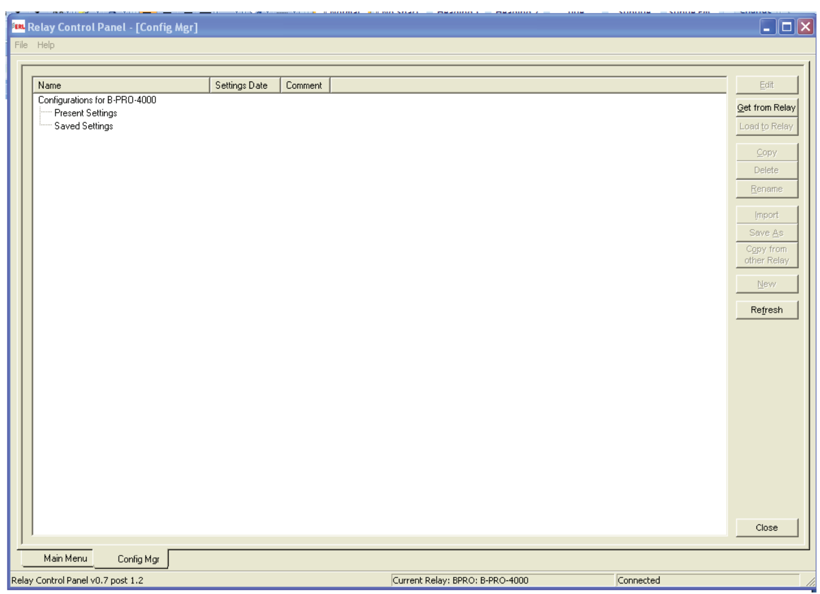



Figure 7.4: Config Manager

In main menu of Relay Control Panel go to *Configuration Manager* either *get from* the setting in the relay or make *New* relay setting (configuration).

# 7.4 Settings and Preliminary Calculations

These are the relevant system parameter settings for tests that follow.

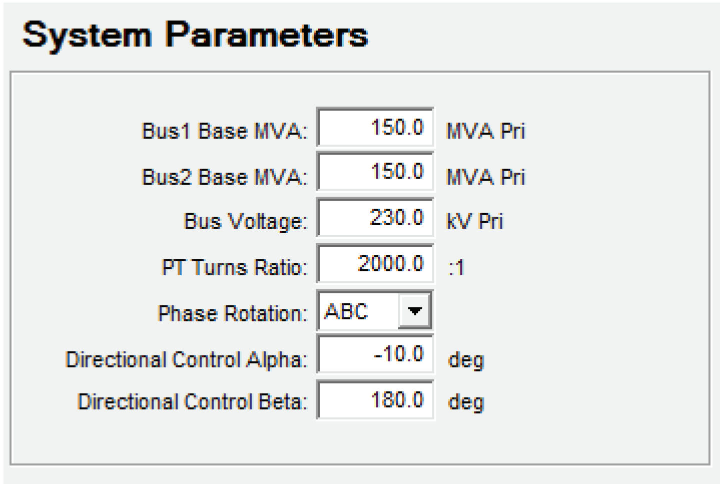



Figure 7.5: System Parameters

These are the relevant Winding/CT settings for tests that follow.

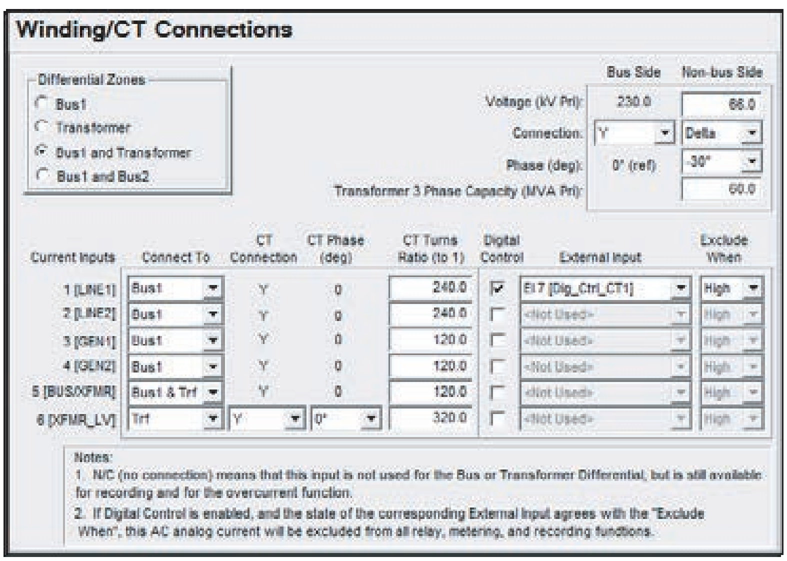



Figure 7.6: Winding CT Connections

### Calculated Values

In the B-PRO relay, the Bus MVA, Bus Voltage and CT Ratio settings are critical in order for the relay to operate correctly for your bus configuration.

We calculate base quantities using the example settings provided in the acceptance test settings file.

Calculate the Primary Base current:

Base Current =

$$\frac{1000 \times BusMVA}{\sqrt{3} \times BuskV} = \frac{1000 \times 150}{\sqrt{3} \times 230} = 376.5A \tag{1}$$

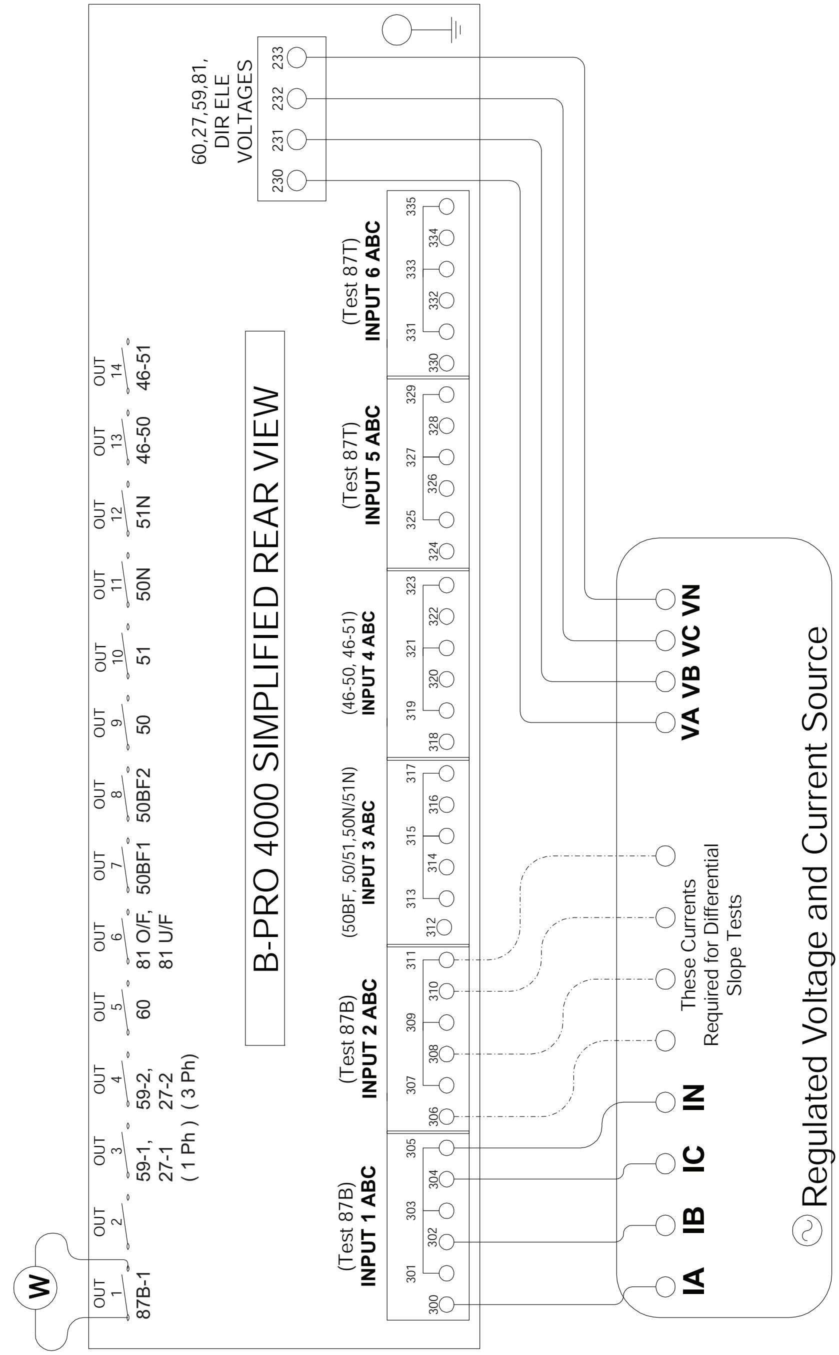



Figure 7.7: Suggested Test Connections for Acceptance Tests

## 60 Functional Test

### 60 Functional Test Settings

(Only Enable Setting can be modified)

Voltage = 0.5 pu on 1 or 2 phases (does not operate on loss of 3 phases).

Calculate secondary phase-to-neutral Voltage from system parameter settings:

$$1.0perUnitV_{secPhaseNeutral} = \frac{PrimaryVolts}{\sqrt{3} \times PTratio} = \frac{230000}{\sqrt{3} \times 2000} = 66.4V \quad (2)$$

$$0.5perUnit = 0.5 \times 66.4V = 32.2V$$

### 60 Functional Test Logic

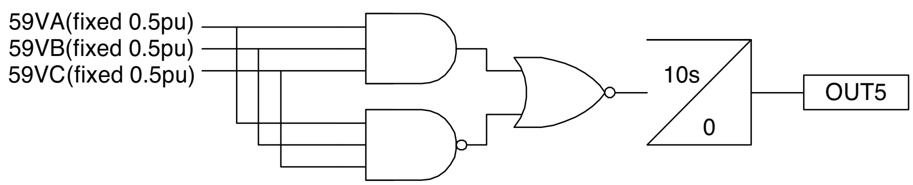



Figure 7.8: Loss Of Potential Acceptance Test Settings and Logic, Mapped to Output 5

### 60 Test Procedure

1. In Relay Control Panel access *B-PRO Metering>Logic.Protection.Logic 3.* Monitor the following element for pickup: 60 Alarm.

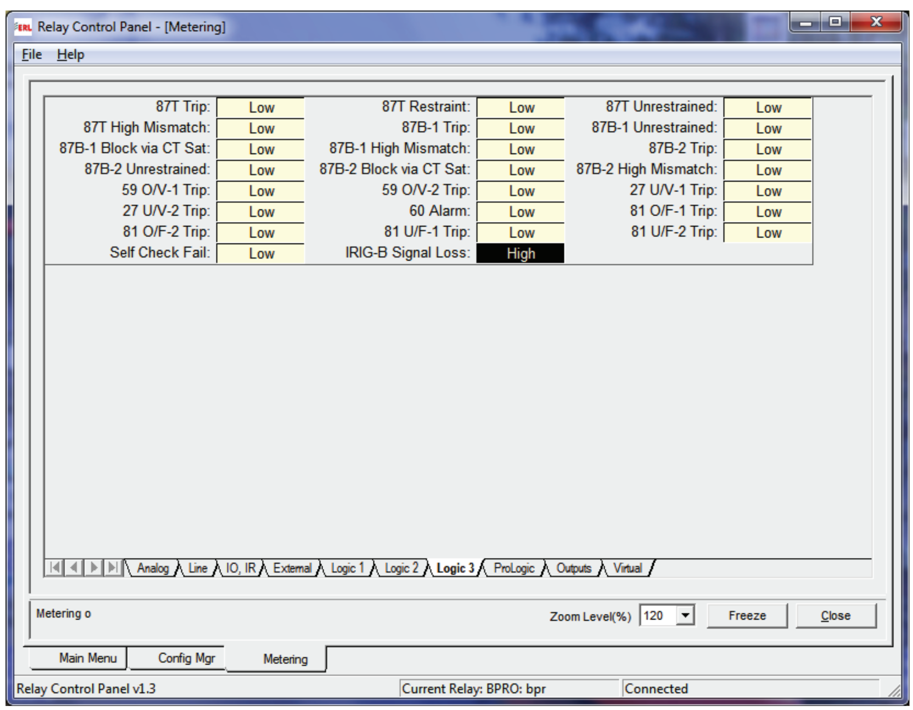



Figure 7.9: Metering Logic 3 (Protection)

2. Apply balanced 3-phase nominal voltages (66.4) to the B-PRO terminals.
   Ph A: 230, 66.4V ∠ 0°
   Ph B: 231, 66.4V ∠ -120°
   Ph C: 232, 66.4V ∠ +120°
   Ph N: 233
   Observe: 60 Alarm = Low
3. Ramp down 1-phase voltage.
   At 33.6 to 32.8 V (expect 33.2 V):
   Observe: 60 Alarm = High
4. Turn all Voltages off.
   Observe: 60 Alarm = Low

### Timing Test

1. Monitor (Timer Stop) on Out 5.
2. Set timer to start from 1-phase 0.0 V to 66.4 V transition (i.e. Volts off to on). For this logic, energizing one phase voltage is the same as loss of two voltages.
   Time Delay (definite) = 10 Seconds

End of 60 test.

## 59 Overvoltage Functional Test

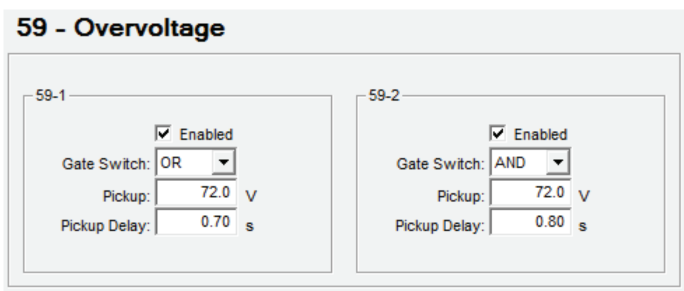



Figure 7.10: 59 Functional Test Settings

### Single-Phase Functional Test Logic

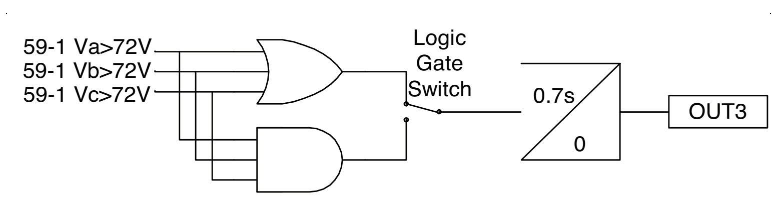



Figure 7.11: Overvoltage Functional Test Settings and Logic, Mapped to Output 3

## Three-Phase Functional Test Logic

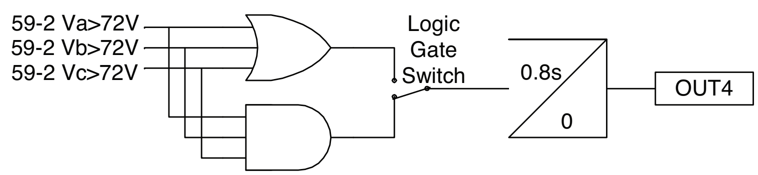



Figure 7.12: Overvoltage Functional Test Settings and Logic, Mapped to Output 4

## 59 Test Procedure

1. In Relay Control Panel access relay access *Metering>Logic>Protection>Logic 3*

   Monitor the following elements for pickup.

   59-1 Trip

   59-2 Trip

   Monitor contacts.

   Out 3 (59-1 Trip)

   Out 4 (59-2 Trip)

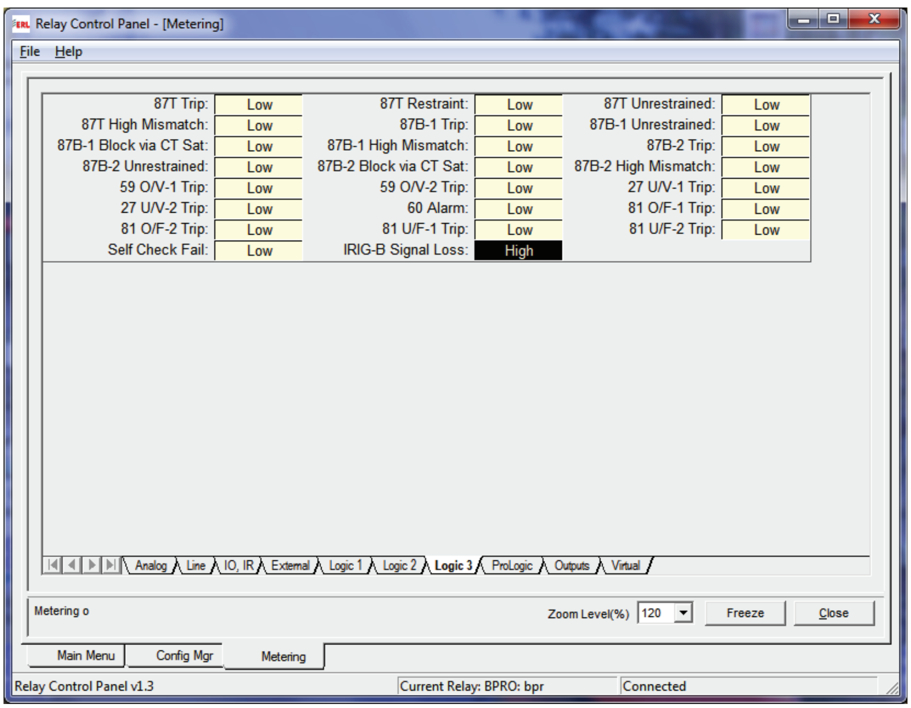



Figure 7.13: Metering Logic 3 (Protection)

2. Apply balanced 3-phase nominal voltages (66.4 V) to the B-PRO terminals.
   Ph A: 230, 66.4V ∠ 0°
   Ph B: 231, 66.4V ∠ -120°
   Ph C: 232, 66.4V ∠ +120°
   Ph N: 233
   Observe: 59-1 Trip = Low
   59-2 Trip = Low
3. Increase A-phase voltage:
   At 70.0 to 74.0 V (expect 72 V):
   Observe: 59-1 Trip = High
   Out 3 = Closed
   Observe: 59-2 Trip remains low
   Out 4 = Open
4. With A-phase voltage still at about 72 V, increase both B- and C-phase voltages:
   At 70 to 74 V (expect 72 V):
   Observe: 59-1 Trip = High
   Observe: 59-2 Trip = High
   Out 4 = Closed

End of 59 test.

## 50N/51N Functional Test

### 50N/51N Functional Test Settings

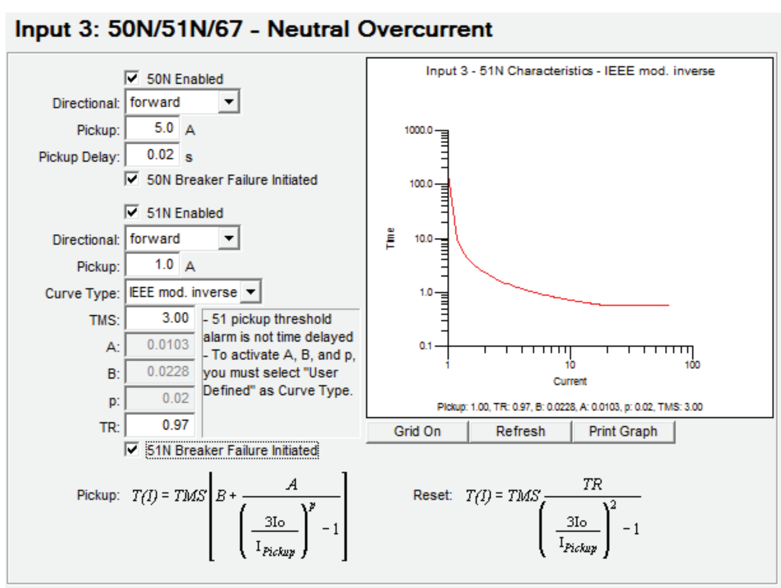



Figure 7.14: 50N/51N/67 Neutral Overcurrent

### 50N/51N Functional Test Logic

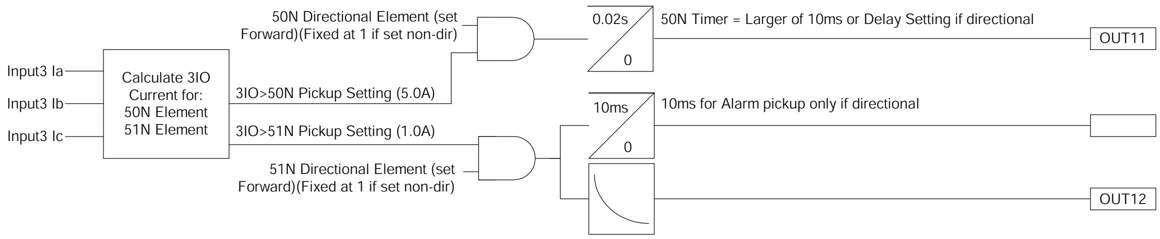



Figure 7.15: 50N/51N Neutral Overcurrent Functional Test Settings and Logic, Mapped to Outputs 11 and 12

### 50N and 51N Test Procedure

Note: With 0 V applied the unit becomes non-directional (i.e. picks up in both forward and reverse directions).

1. In Relay Control Panel access relay *Metering>Logic>Protection>Logic1.*

   Monitor the following element for pickup: Gen1 51N Alarm.

   Monitor normally open Out 11 (Gen1 50N Trip).

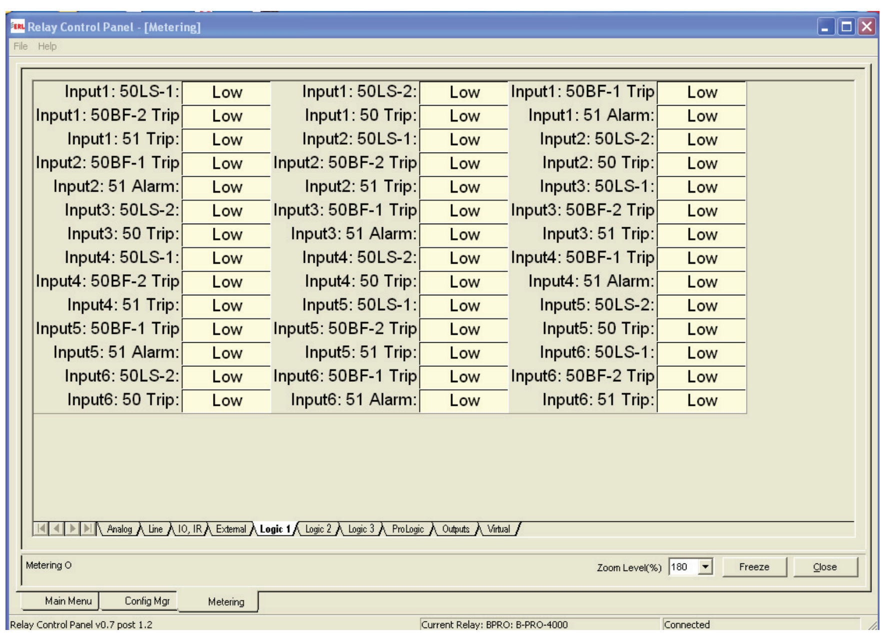



Figure 7.16: Metering Logic 1 (Protection)

2. Apply single-phase current to the B-PRO terminals as follows:

   Ph A: 312 – 313, 0.5 A

3. Slowly ramp the current up.

   At 0.95 – 1.05 A (expect 1.0 A)

Observe: Gen1 51N Alarm = High

4. Continue to raise current.

At 4.9 – 5.1 A (expect 5.0 A):

Observe: Gen1 50N Trip = High

Out 11 = Closed

5. Turn current off.

Observe: Gen1 51N Alarm = Low

Observe: Gen1 50N Trip = Low

**51N Timing Test**

1. Monitor (Timer Stop) on Out 12.
2. Set timer start from single-phase 0.0 A to 4.00 A transition (this equates to 4x pickup).

Time Delay =

$$TMS \times \left[B + \frac{A}{(I_{multiple})^{P} - 1}\right] = 3 \times \left[0.0228 + \frac{0.0103}{(4)^{0.02} - 1}\right] = 3 \times \left[0.0228 + \frac{0.0103}{0.0281}\right] = 1.17s \quad (3)$$

3. Apply current for longer than 1.2 seconds (relay trips in 1.17 seconds).

Relay Target: Gen1 51N Trip

End of 50N/51N test.

## 50/51 Functional Test

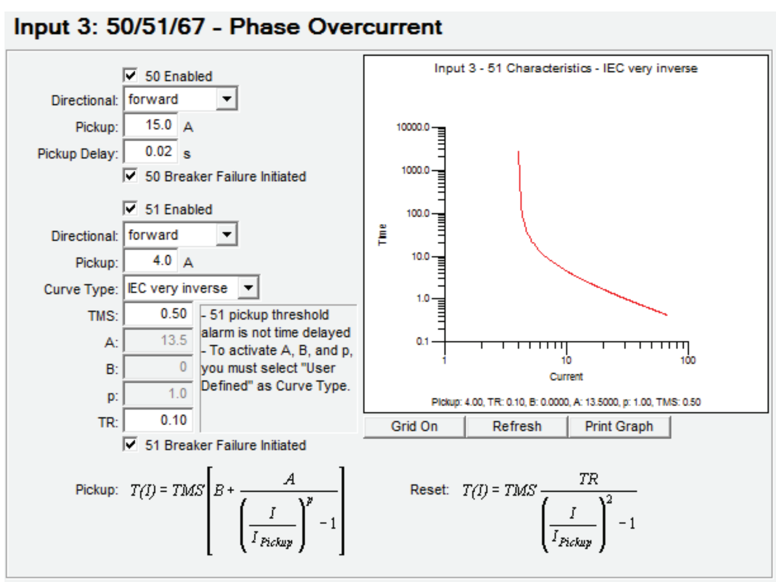



Figure 7.17: 50 and 51 Functional Test Settings

### 50/51 Functional Test Logic

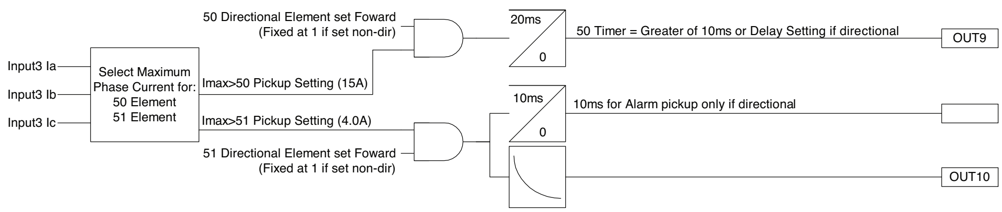



Figure 7.18: : 50/51 Overcurrent Functional Test Settings and Logic, Mapped to Outputs 9 and 10

### 50 and 51 Test Procedure

1. In Relay Control Panel access relay *Metering>Logic>Protection>Logic1*.

    Monitor for pickup: Gen1 51 Alarm

    Monitor normally open Out 9 (Gen1 50 Trip)

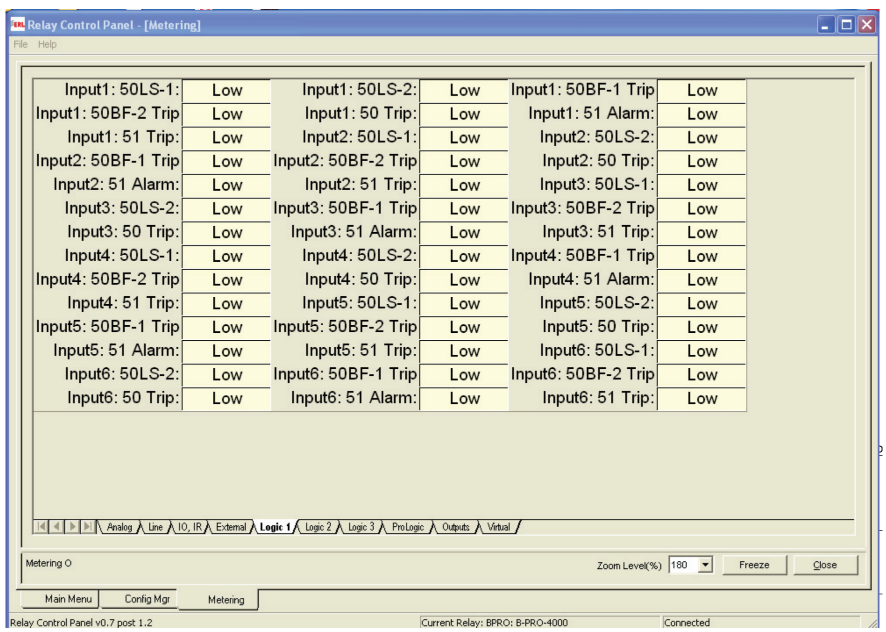



Figure 7.19: Metering Logic 1 (Protection)

2. Apply single-phase current to the B-PRO terminals as follows:

    Ph A: 312 – 313, 3.5 A

3. Slowly ramp the current up.

    At 3.8 – 4.2 Amps (expect 4.0 A):

    Observe: Gen1 51 Alarm = High

4. Continue to raise currents.

    At 14.3 – 15.8 A (expect 15 A)

    Observe: Gen1 50 Trip = High

    Out 9 = Closed

5. Turn currents off.

   Observe: Gen1 51 Alarm = Low

   Observe: Gen1 50 Trip = Low

**51 Timing Test**

1. Monitor (Timer Stop) on Out 10.
2. Set Timer Start from single-phase 0.0 A to 16.00 A transition (this equates to 4x pickup).

Time Delay =

$$TMS \times \left[B + \frac{A}{(I_{multiple})^P - 1}\right] = 0.5 \times \left[0.00 \times \frac{13.5}{(4)^1 - 1}\right] = 0.5 \times \left[0.00 + \frac{13.5}{3}\right] = 2.25s \tag{4}$$

3. Inject current for about 2.5 seconds (relay trip in 2.25 seconds).

   Relay Target: Gen1 51 on A Trip

## Directional Element Functional Test

**Directional Element Functional Test Settings**

51 Settings as above

Directional Range angle settings (from System Parameters):

Alpha = -10°

Beta = 180°

$$LineAngle = Alpha + \frac{Beta}{2} = \left((-10) + \frac{180}{2}\right) = 80° \tag{5}$$

(i.e. Current lags Voltage by 80)

**Directional Element Functional Test Logic**

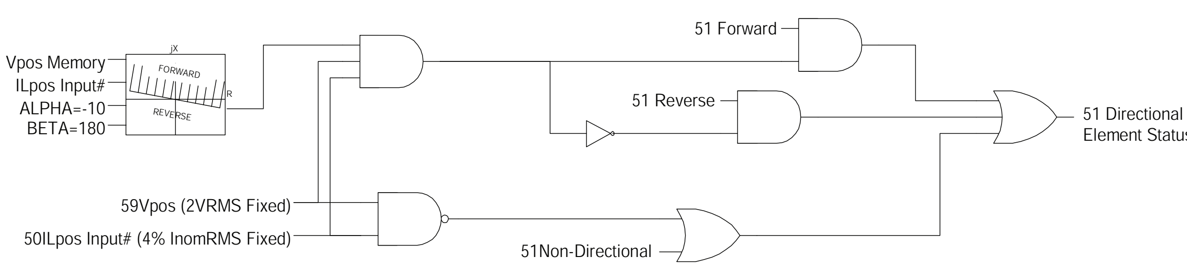



Figure 7.20: Directional Element Logic (only 51 portion shown)

The B-PRO directional element uses a fixed positive sequence current supervision of 4% x $I_{nominal}$. If the positive sequence current falls below 4% of $I_{nominal}$ the directional control becomes non-directional (i.e. may operate for forward or reverse faults).

### 51 Directional Test Procedure

1. In Relay Control Panel access relay *Metering>Logic>Protection>Logic1*.
   Monitor the following element for pickup: Gen1 51 Alarm.

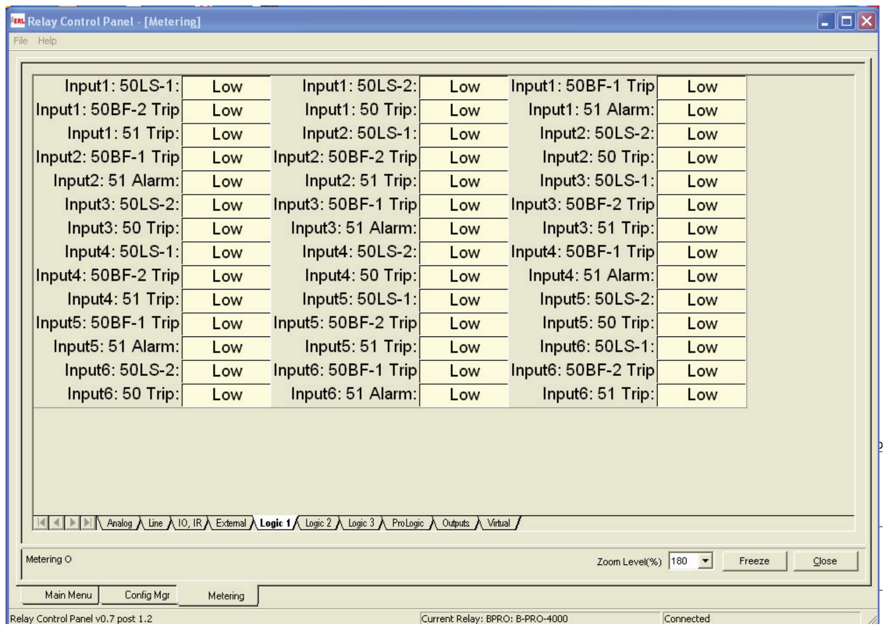



Figure 7.21: Metering Logic 1 (Protection)

2. Apply single-phase polarizing voltage to:
   Ph A: 230 – 233, 66.4 V ∠ 0°
3. Apply single-phase current to the B-PRO terminals as follows:
   Ph A: 312 – 313, 5.0A ∠ -80°
      Observe: Gen1 51 Alarm = High
4. Slowly ramp the current phase angle in negative direction (i.e. more lag).
   At -165° to -175° (expect -170°).
      Observe: Gen1 51 Alarm = Low.
5. Return current angle to -80°
      Observe: Gen1 51 Alarm = High
6. Slowly ramp the current phase angle in positive direction (i.e. less lag).
   At +5° to +15° (expect +10°)
      Observe: Gen1 51 Alarm = Low
7. Turn off voltage and current sources.

End of Directional Test.

## 50BF Functional Test

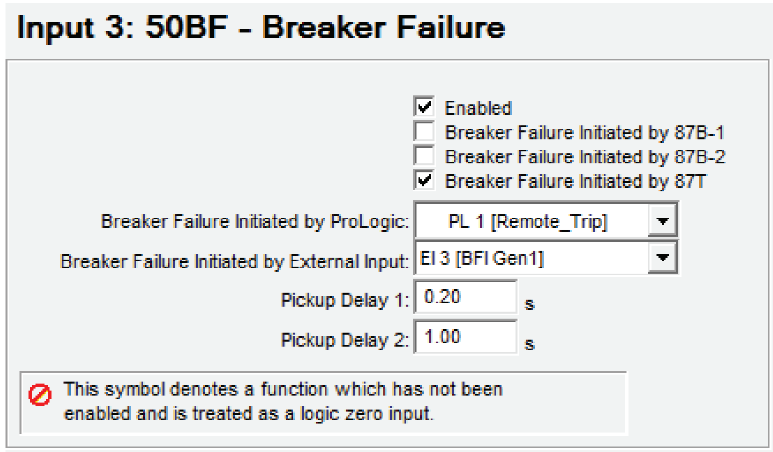



Figure 7.22: 50BF Functional Test Settings

### 50BF Functional Test Logic

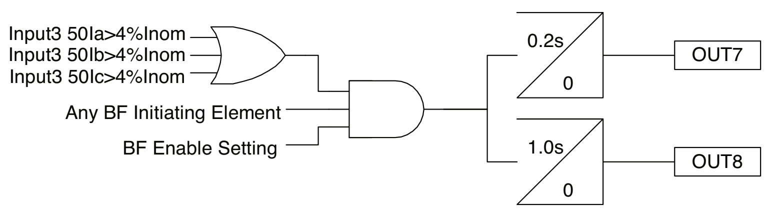



Figure 7.23: 50BF Breaker Fail Functional Test Settings and Logic, Mapped to Outputs 7 and 8

| |
|---|
| NOTE: Require a Minimum of 0.2 A on any phase to arm the Breaker Fail. |

**50BF Test Procedure**

1. In Relay Control Panel access relay *Metering>I/O*.
   Monitor normally open Out 7 (50BF-Level 1)
   Monitor normally open Out 8 (50BF-Level 2)

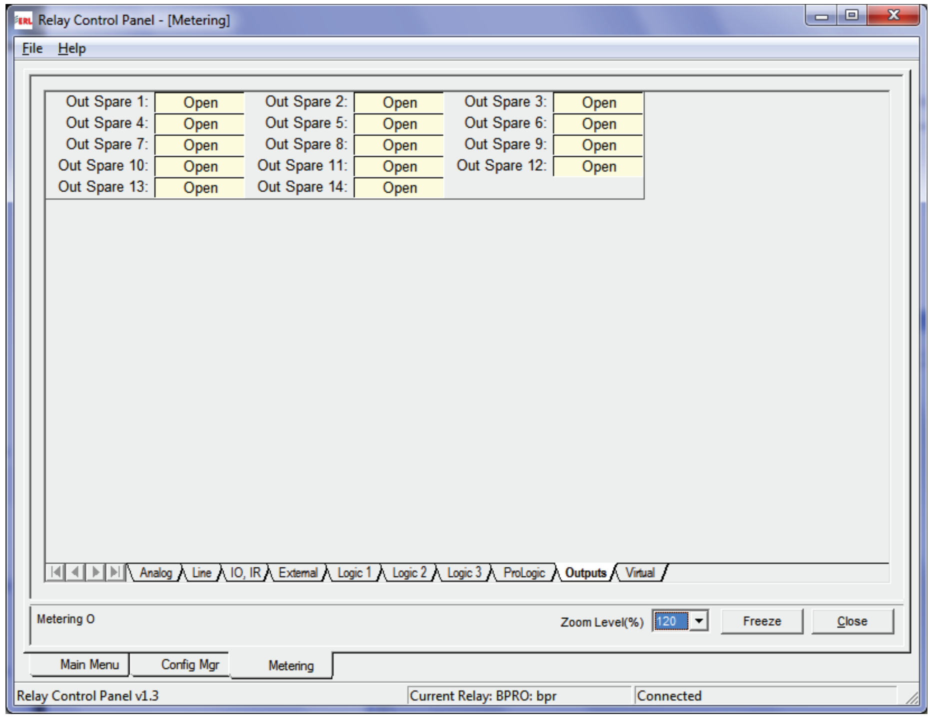



Figure 7.24: Output Contacts

2. Apply single-phase current to the B-PRO Input 3 terminals as follows.
   Ph A: 312 – 313, 6.0 A (this will trip 50N and initiate the Breaker Fail)
   After 200 milliseconds:
   Observe: Input 3 50BF-Level 1 = High
   Out 7 = Closed
   After additional 800 milliseconds:
   Observe: Input 3 50BF-Level 2 = High
   Out 8 = Closed
3. Turn current off.
   Observe: 50BF Elements = Low
   Observe: Out 7 & Out 8 = Open

End of Breaker Fail Test.

## 46-50/46-51 Functional Test

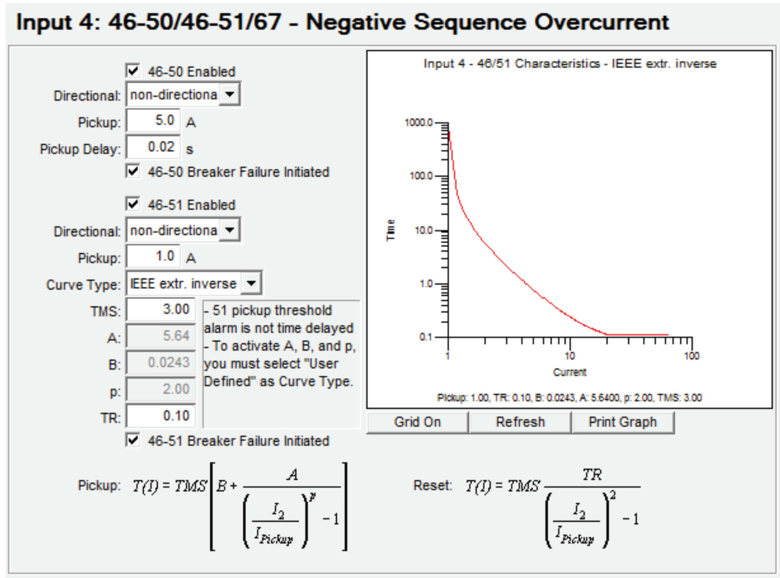



Figure 7.25: 46-50 and 46-51 Functional Test Settings

### 46-50/46-51 Functional Test Logic

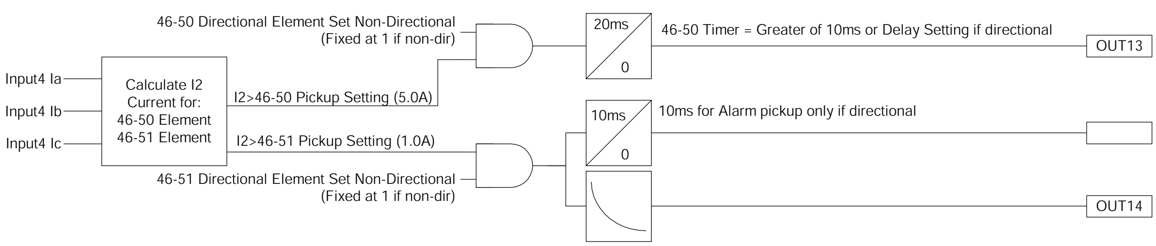



Figure 7.26: 46-50/46-51 Negative Sequence Overcurrent Functional Test settings and Logic Mapped to Outputs 13 and 14

For this test we will inject only single-phase current. This method introduces an equal proportion of positive and negative sequence current. This assures that if your negative sequence overcurrent element is set to be directional (Forward or Reverse), then there is sufficient positive sequence current to enable directional control of the negative sequence element. Note that directional control, if used, will also require that at least one phase of polarizing voltage be applied to the B-PRO voltage input.

Positive sequence ($I_1$), Negative Sequence ($I_2$), Zero Sequence ($3I_0$) are calculated by using the following equations:

$$I_2 = \frac{I_A + aI_B + a^2 I_C}{3} \qquad \text{where a} = 1 \angle 120° \tag{6}$$

$$I_2 = \frac{I_A + a^2 I_B + aI_C}{3} \qquad a = 1 \angle 120°$$

$$3I_O = I_A + I_B + I_C$$

If we inject only Phase A current using Equation 2, triple the pickup setting current on the single phase to obtain the pickup value of negative sequence current.

For example, injecting 1.0 A on Phase A only (Phase B = Phase C = 0).

$$I_2 = \frac{1.0A + a^2 0A + a0A}{3} = \frac{1A}{3} = 0.33A$$

**46-51 Test Procedure**

1. In Relay Control Panel access relay *Metering>Logic>Protection>Logic1*.
   Monitor the following element for pickup: Gen2 46-51 Alarm.

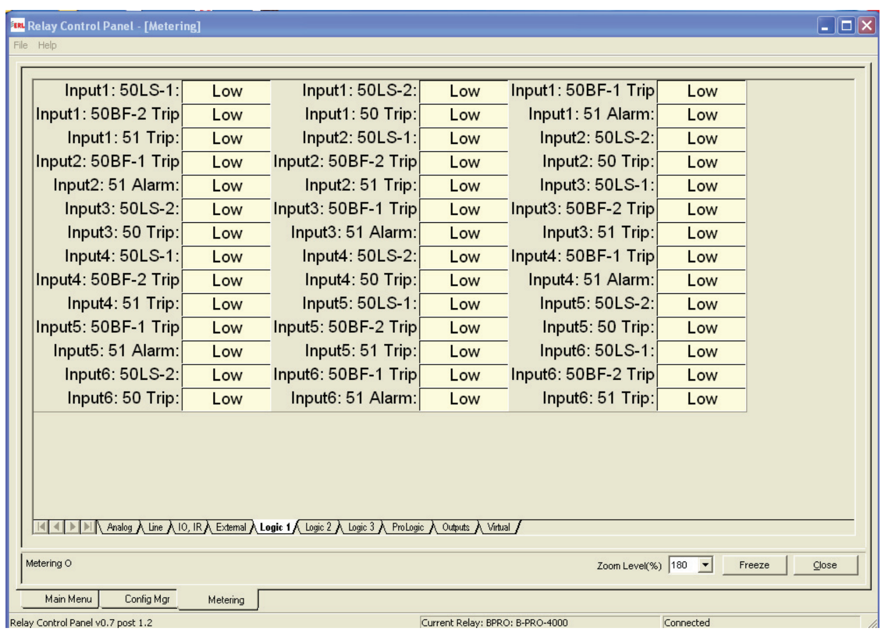



Figure 7.27: Metering Logic 1 (Protection)

2. Apply single-phase current to the B-PRO terminals as follows.
   Ph A: 318 – 319, 2.5 A

3. Slowly ramp the current up.
   At 2.9 – 3.1 A (expect 3.0 A):
   Observe: Input 4 Gen2 Pickup Alarm = High
4. Turn current source off.

**46-51 Timing Test**

1. Monitor (Timer Stop) on Out 14.
2. Set timer start from single-phase 0.0 A to 12.00 A transition (this equates to 4x pickup).

Time Delay =

$$TMS \times \left[B + \frac{A}{(I_{multiple})^P - 1}\right] = 3 \times \left[0.02434 + \frac{5.64}{(4)^2 - 1}\right] = 3 \times \left[0.02434 + \frac{5.64}{15}\right] = 1.20s \qquad (7)$$

3. Inject current for longer than 1.5 seconds (relay trip in 1.20 seconds).
   Observe relay target: Gen2 46-51 Trip

End of 46-51 test.

**46-50 Test Procedure**

1. In Relay Control Panel access relay *Metering>Logic>Protection>Logic1*.
   Monitor the following element for pickup: Gen2 46-50 Trip
   Monitor normally open Out 13 (Gen2 46-50 Trip)
2. Apply single-phase current to the B-PRO terminals as follows:
   Ph A: 318 – 319, 14.0 A
3. Ramp the current up.
   At 14.3 – 15.7 A (expect 15.0 A):
   Observe: Gen2 46-50 Trip = High
   Out 13 = Closed
4. Turn current source off.

End of 46-50 Trip.

## 81 Functional Test

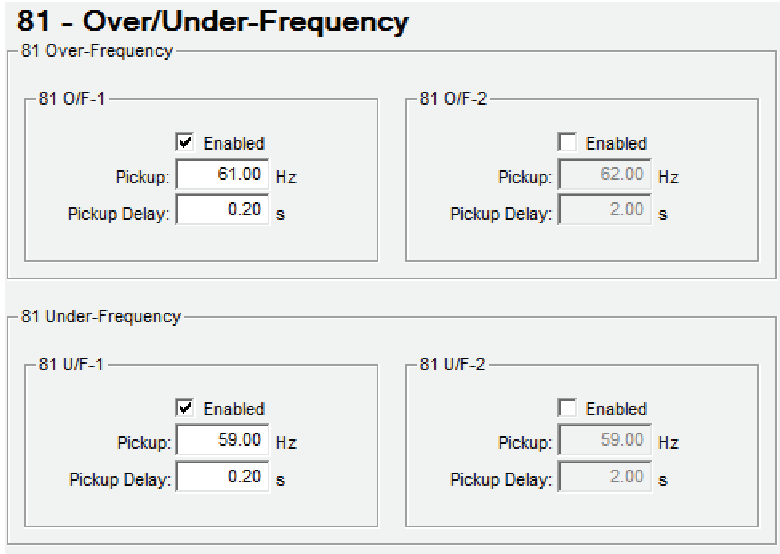



Figure 7.28: 81 Functional Test Settings

### 81 O/F Functional Test Logic

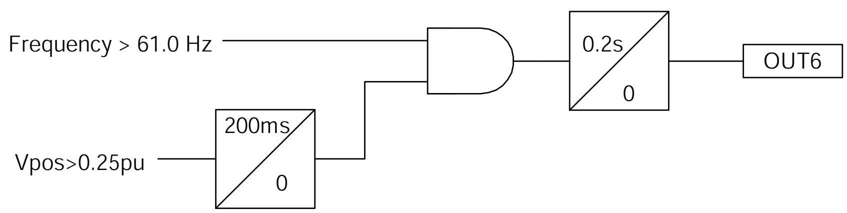



Figure 7.29: O/F-1 Overfrequency Functional Test Settings and Logic Mapped to Output 6

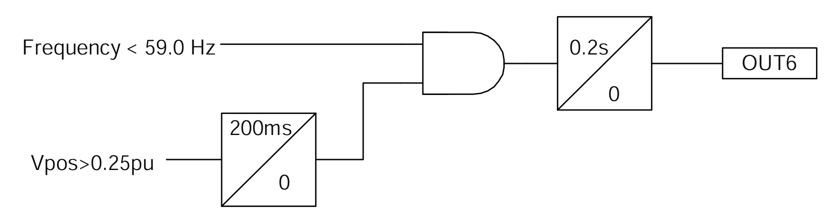



Figure 7.30: 81 U/F-1 Underfrequency Functional Test Settings and Logic, Mapped to Output 6

### 81 Test Procedure

1. In Relay Control Panel, access B-PRO *Metering>Logic>Protection>Logic 2.*

   Monitor the following elements for pickup: 81 O/F-1 Trip, 81 U/F-1 Trip.

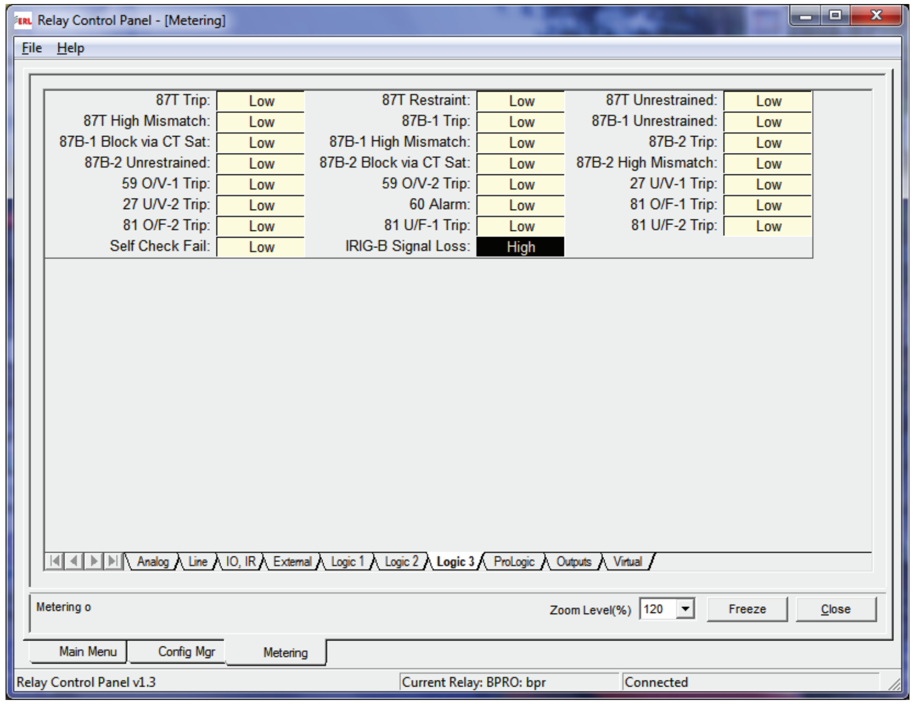



Figure 7.31: Metering Logic 3 (Protection)

2. Apply balanced 3-phase nominal voltages to the B-PRO terminals.

   Ph A: 230, 66.4V ∠0°

   Ph B: 231, 66.4V ∠-120°

   Ph C: 232, 66.4V ∠+120°

   Ph N: 233

3. Slowly ramp the 3-phase voltage frequency up toward 61 Hz.

   At 60.99 – 61.01 Hz:

   Observe: 81 O/F-1 = High

   Out 6 = Closed

4. Slowly ramp the 3-phase voltage frequency down toward 59 Hz.

   At 58.99 – 59.01 Hz:

   Observe: 81 U/F-1 = High (81 O/F-1 = Low)

   Out 6 = Closed

5. Turn voltages off:

   Observe: 81 O/F-1 = Low

   Observe: 81 U/F-1 = Low

   Out 6 = Open

End of 81 Test.

## 87B Bus Differential Minimum Operate Functional Test

This section will cover the testing of the minimum operating point for Input 1 and for one phase only. Other Inputs 2 through Input 5 and all other phases can be tested by using the same process. For more detailed testing see "87B Slope Functional Test:" on page 7.-27.

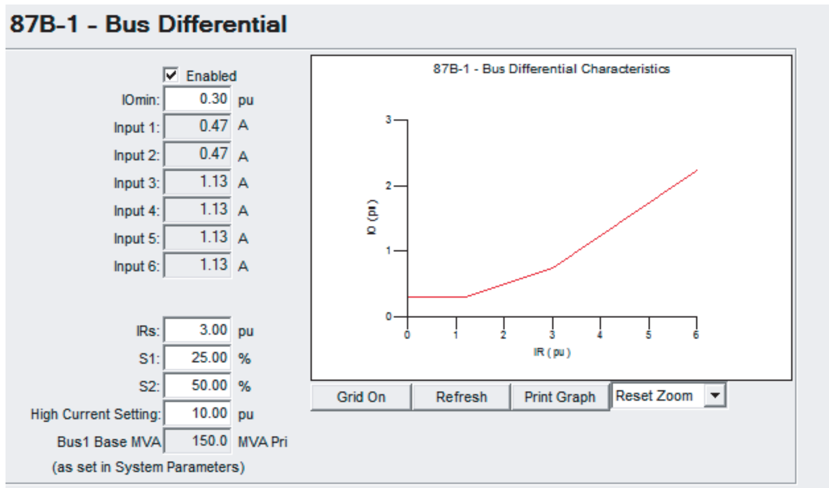



Figure 7.32: 87B Functional Test Settings

Some necessary calculations in order to work in Amperes:

Bus Base Current = 376.5 A primary (as calculated previously)

Input 1 CT Ratio = 240:1

Input 1 Base Current = Primary Base/CT Ratio = 376.5 A/240 = 1.57 A secondary

$IO_{min}$: 0.3 pu (0.47 A secondary)

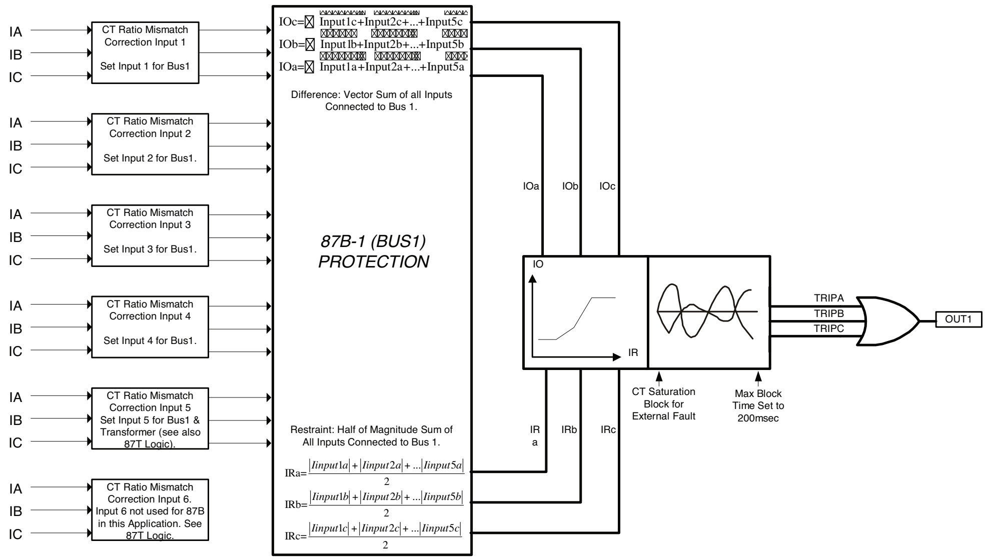



Figure 7.33: Figure 11: 87B Bus Differential Functional Test Settings and Logic M

### 87B Minimum Operate Test Procedure

1. In Relay Control Panel access B-PRO *Metering>Logic>Protection>Logic 2.*

   Monitor the following element for pickup: 87B-1 Trip.

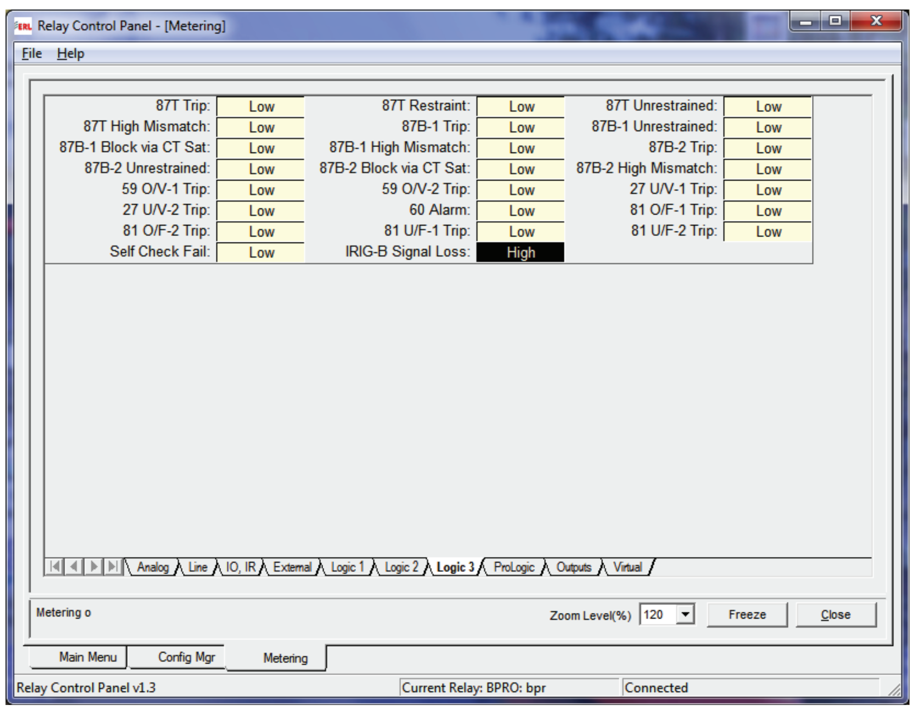



Figure 7.34: Metering Logic 3 (Protection)

2. Prepare to apply single-phase current to the B-PRO terminals as follows:
   Ph A: 300 – 301, ∠ 0°
3. Ramp the currents up.
   At 0.45 A to 0.49 A (Expect 0.47 A):
      Observe: 87B-1 Trip = High
      Out 1 = Closed
4. B-PRO Target: 87B-1 Trip on A
5. Apply the same test to phases B and C and other Inputs as required.

End of 87B minimum operate test.

#### 87B Slope Functional Test:

Slope testing is used to define the 87B operate/restraint characteristic. The purpose, essentially, is to test the differential element security for external or "through" faults.

Note: We demonstrate slope testing using Phase A of Input 1 to Phase A of Input 2 for this example. Other inputs and phases may also be tested as required using the same process demonstrated here.

#### Settings for the 87B-1 differential element (as previously listed):

$IO_{min}$ = 0.3 per unit
IRS = 3.0 per unit
S1 = 25%
S2 = 50%
Input 1 CT Ratio = 240:1
Input 2 CT Ratio = 240:1

#### Steps to Test B-PRO Bus Differential Slope

A Create a Test Table.

B Establish the Base Current, first in primary, then in secondary for each input. Also derive the Magnitude Correction Factor (MCF) which is the balance point for slope testing.

C Calculate the currents required at each input to test specific points on the 87B characteristic.

D Inject the relay according to your calculations to verify the settings and relay performance.

**We Begin:**

A Create a Test Table such as the following, to document your test data. (Note: we include the data from the preceding 87B Minimum Operate test).

| Point To Test | IO (per Unit) | IR (per Unit) | Input 1 Expected (Amps) @ 0° | Input 1 Test Actual (Amps) | Input 2 Expected (Amps) @ 180° | Input 2 Test Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.47A (pickup if injecting input 1 only) | | 0.47A (pickup if injecting input 2 only) | |
| IRmin | | | | | | |
| IRs | | | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

B Establish the base current.

For this example, the Bus Base Current as calculated previously is 376.5 A primary.

- Input 1 Base Current = 376.5 A / Input 1 CT Ratio = 376.5 / 240 = 1.57 A secondary

- Input 2 Base Current = 376.5 A / Input 2 CT Ratio = 376.5 / 240 = 1.57 A secondary

Calculate the Magnitude Correction Factor = which is the ratio of the Input 2 $IO_{min}$ current to Input 1 $IO_{mi}$n current, or vice versa (values from the Test Table).

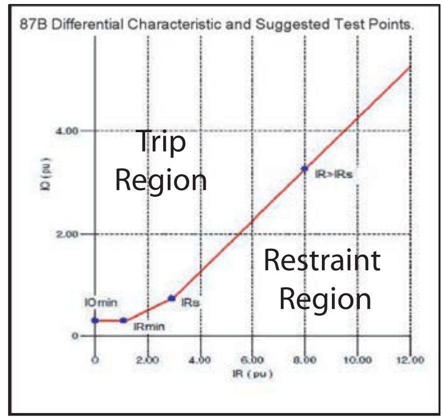
We chose Input 2 / Input 1 for this scenario.

$$MCF = \frac{IOmin_{Input2}}{IOmin_{Input1}} = \frac{0.47A}{0.47A} = 1.0 \qquad (8)$$

I Calculate the currents required at each input to test specific points on the 87B characteristic.

The graph at the right shows some typical points which may be tested to prove the slope characteristic.

Method to calculate the required test currents shall follow.




Determine the IO and IR current values on the 87 Slope (through-fault restraint characteristic) where the B-PRO 87B element will operate. Determine the current pickup values of current for any values of IO and IR on the curve.

The following equations for Operate and Restraint current ("87 Equation 1" and "87 Equation 2") will be used to determine the test currents for the 87 slope characteristic:

$$IO = [Input1 + [Input2 \tag{9}$$

OR

$$IO = |I_{Input1}| - |I_{Input2}|$$ for an ideal through fault

$$IR = \frac{|I_{Input1}| + |I_{Input2}|}{2} \tag{10}$$

**Point 1**

$IO_{min}$

The $IO_{min}$ point is simplest to calculate. It is simply the $IO_{min}$ per unit setting multiplied by the secondary base current. This is true for any input to be tested. The $IO_{mi}$n point has already been tested previously so we will not repeat the test here.

The next point to calculate is $IR_{min}$. This is the point where the Slope 1 begins, or where the Restraint current will begin to affect the amount of difference current required to operate the 87B. Once the restraint current exceeds $IR_{min}$, the amount of Operate (i.e. Difference) current required to operate the 87B shall increase.

**Point 2**

Calculate Currents to Test IR = $IR_{min}$ (Minimum Restraint Current = 1.5 per Unit).

$$IO = \frac{S1 \times IR_{min}}{100} \tag{11}$$

$$0.3 = \frac{25 \times IR_{min}}{100}$$

Isolate $IR_{min}$

$$IR_{min} = \frac{30}{25} = 1.20pu \tag{12}$$

Note at IR = $IR_{min}$, IO = $IO_{min}$ = 0.3pu

Therefore, with $IO_{min}$ = 0.3 per unit and Slope 1 = 25%, $IR_{min}$ = 1.2 per unit.

Enter the IO and IR points into your test table:

| Point To Test | IO (per Unit) | IR (per Unit) | Input 1 Expected (Amps) @ 0° | Input 1 Test Actual (Amps) | Input 2 Expected (Amps) @ 180° | Input 2 Test Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.47A | | 0.47A | |
| IRmin | 0.3 | 1.2 | | | | |
| IRs | | | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

Solve for Input 1 and Input 2 test currents to give:

IO = 0.3 pu

$IR_{min}$ = 1.2 pu

Use above 87 Equation 2 and 87 Equation 3 to solve for test currents.

Isolate $I_{Input1}$ and $I_{Input2}$ on the right side of the IO and IR equations:

$$IO = |I_{Input1}| - |I_{Input2}| \tag{13}$$

$$0.3 = |I_{Input1}| - |I_{Input2}|$$

$$IR = \frac{|I_{Input1}| + |I_{Input2}|}{2} \tag{14}$$

$$1.2 = \frac{|I_{Input1}| + |I_{Input2}|}{2}$$

$$1.2 \times 2 = |I_{Input1}| + |I_{Input2}|$$

$$2.4 = |I_{Input1}| + |I_{Input2}|$$

Add and subtract the two above equations find $I_{Input1}$ and $I_{Input2}$ to determine the currents required to operate the 87B element.

Solve for $I_{Input1}$ by adding the two equations together:

$$0.3 = |I_{Input1}| - |I_{Input2}|$$

$$+\ 2.4 = |I_{Input1}| + |I_{Input2}|$$

$$\text{Total} = 2.7 = 2|I_{Input1}| + 0|I_{Input2}|$$

$$\frac{2.7}{2} = |I_{Input1}| = 1.35pu$$

$$I_{Input1_{amps}} = I_{Input1BaseSec} \times I_{Input1_{perUnit}} = 1.57A \times 1.35pu = 2.12A$$

Solve for $I_{Input2}$ by subtracting the two equations:

$$0.3 = |I_{Input1}| - |I_{Input2}|$$

$$-\ 2.4 = |I_{Input1}| + |I_{Input2}|$$

$$\text{Total} = -2.1 = 0|I_{Input1}| - 2|I_{Input2}|$$

$$\frac{-2.1}{-2} = |I_{Input2}| = 1.05pu$$

$$I_{Input2_{amps}} = I_{Input2BaseSec} \times I_{Input2_{perUnit}} = 1.57A \times 1.05pu = 1.65A$$

Enter the Input 1 and Input 2 test currents into your test table.

| Point To Test | IO (per Unit) | IR (per Unit) | Input 1 Expected (Amps) @ 0° | Input 1 Test Actual (Amps) | Input 2 Expected (Amps) @ 180° | Input 2 Test Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.47A | | 0.47A | |
| IRmin | 0.3 | 1.2 | 2.12A | | 1.65A | |
| IRs | | | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

**Point 3**

Calculate test currents for IR = IRs = 3.0 per unit.

The next point to calculate is currents at IR = IRs. This is the point on the 87 characteristic where Slope 1 ends and the Slope 2 begins.

First, calculate the value of IO at IRs using the following 87 Equation 4.

$$IO = \frac{S2 \times IR}{100} + \frac{S1 - S2}{100}\ IRs \qquad (15)$$

$$IO = \frac{50 \times 3.0}{100} + \frac{25 - 50}{100}\ 3.0s$$

$$O = \langle 1.5 + \langle -0.75 \rangle \rangle$$

$$IO = 0.75pu$$

Therefore with Slope 1 = 25% and Slope 2 = 50%, if IRs = 3.0 per unit then IO = 0.75 per unit.

Enter the IO and IR points into your test table.

| Point To Test | IO (per Unit) | IR (per Unit) | Input 1 Expected (Amps) @ 0° | Input 1 Test Actual (Amps) | Input 2 Expected (Amps) @ 180° | Input 2 Test Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.47A | | 0.47A | |
| IRmin | 0.3 | 1.2 | 2.12A | | 1.65A | |
| IRs | 0.75 | 3.0 | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

Solve for Input 1 Current and Input 2 Current to give:

IO = 0.75 pu

IRs = 3.0 pu

Use above 87 Equation 2 and 87 Equation 3 to solve for test currents.

Isolate $I_{Input1}$ and $I_{Input2}$ on the right side of the IO and IR equations:

$$IO = |I_{Input1}| - |I_{Input2}| \tag{16}$$

$$0.75 = |I_{Input1}| - |I_{Input2}|$$

$$IR = \frac{|I_{Input1}| + |I_{Input2}|}{2} \tag{17}$$

$$3.0 = \frac{|I_{Input1}| + |I_{Input2}|}{2}$$

$$6.0 = |I_{Input1}| + |I_{Input2}|$$

Add and subtract the two above equations find $I_{Input1}$ and $I_{Input2}$ to determine the currents required to operate the 87B element.

Solve for $I_{Input1}$ by adding the above two equations together:

$$0.75 = |I_{Input1}| - |I_{Input2}|$$

$$+\ 6.0 = |I_{Input1}| + |I_{Input2}|$$

$$\text{Total} = 6.75 = 2|I_{Input1}| - 0|I_{Input2}|$$

$$\frac{6.75}{2} = |I_{Input1}| = 3.375pu$$

$$I_{Input1Amps} = I_{Input1BaseSec} \times I_{Input1perunit} = 1.57A \times 3.37A = 5.30A$$

Solve for $I_{Input2}$ by subtracting the two equations:

$$0.75 = |I_{Input1}| - |I_{Input2}|$$

$$-6.0 = |I_{Input1}| + |I_{Input2}|$$

$$\text{Total} = -5.25 = 0|I_{Input1}| - 2|I_{Input2}|$$

$$\frac{-5.25}{-2} = |I_{Input2}| = 2.625pu$$

$$I_{Input2_{Amps}} = I_{Input2BaseSec} \times I_{Input2_{perunit}} = 1.57A \times 2.625pu = 4.12A$$

Enter the Input 1 and Input 2 test currents into your test table.

| Point To Test | IO (per Unit) | IR (per Unit) | Input 1 Expected (Amps) @ 0° | Input 1 Test Actual (Amps) | Input 2 Expected (Amps) @ 180° | Input 2 Test Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.47A | | 0.47A | |
| IRmin | 0.3 | 1.2 | 2.12A | | 1.65A | |
| IRs | 0.75 | 3.0 | 5.30A | | 4.12A | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

**Point 4**

Testing of IR > IRs

The next point to calculate are the currents at some point of IR>IRs. This is a point on the 87 Slope 2.

Calculate currents to test IR > IRs (Let IR = 8.0 pu)

First, calculate the value of IO at IR of 8.0 using the following 87 Equation 4.

$$IO = \frac{S1 \times IR}{100} + \frac{S1 - S2}{100} \times IRs \tag{18}$$

$$IO = \frac{50 \times 8.0}{100} + \frac{25 - 50}{100} \times 3.0$$

$$IO = \langle 4.0 + \langle -0.75 \rangle \rangle$$

$$IO = 3.25pu$$

Therefore with Slope 1 = 25% and Slope 2 = 50%, if IO = 3.25 per unit then IO = 8.0 per unit.

Enter the IO and IR points into your test table.

| **Point To Test** | **IO (per Unit)** | **IR (per Unit)** | **Input 1 Expected (Amps) @ 0°** | **Input 1 Test Actual (Amps)** | **Input 2 Expected (Amps) @ 180°** | **Input 2 Test Actual (Amps)** |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.47A | | 0.47A | |
| IRmin | 0.3 | 1.2 | 2.12A | | 1.65A | |
| IRs | 0.75 | 3.0 | 5.30A | | 4.12A | |
| IR>IRs | 3.25 | 8.0 | | | | |
| Etc. | | | | | | |

Solve for Input 1 Current and Input 2 Current to give:

IO = 3.25 pu

IR = 8.0 pu

Use above 87 Equation 2 and 87 Equation 3 to solve for test currents.

Isolate $I_{Input1}$ and $I_{Input2}$ on the right side of the IO and IR equations:

$$IO = |I_{Input1}| - |I_{Input2}| \tag{19}$$

$$3.25 = |I_{Input1}| - |I_{Input2}|$$

$$IR = \frac{|I_{Input1}| + |I_{Input2}|}{2} \tag{20}$$

$$8.0 = \frac{|I_{Input1}| + |I_{Input2}|}{2}$$

$$16.0 = |I_{Input1}| + |I_{Input2}|$$

Add and subtract the two above equations find $I_{Input1}$ and $I_{Input2}$ to determine the currents required to operate the 87B element.

Solve for $I_{Input5}$ by adding the two equations together.

$$3.25 = |I_{Input1}| - |I_{Input2}|$$

$$+\ 16.0 = |I_{Input1}| + |I_{Input2}|$$

$$\text{Total} = 19.25 = 2|I_{Input1}| + 0|I_{Input2}|$$

$$\frac{19.25}{2} = |I_{Input1}| = 9.625pu$$

$$I_{Input1_{Amps}} = I_{Input1BaseSec} \times I_{Input1_{perunit}} = 1.57A \times 9.625pu = 15.11A$$

Solve for $I_{Input6}$ by subtracting the two equations:

$$3.25 = |I_{Input1}| - |I_{Input2}|$$

$$-\ 16.0 = |I_{Input1}| + |I_{Input2}|$$

$$\text{Total} = -12.75 = 0|I_{Input1}| - 2|I_{Input2}|$$

$$\frac{12.75}{-2} = |I_{Input2}| = 6.375pu$$

$$I_{Input2_{Amps}} = I_{Input2BaseSec} \times I_{Input2_{perunit}} = 1.57A \times 6.375pu = 10.01A$$

Enter the Input 1 and Input 2 test currents into your test table.

| **Point To Test** | **IO (per Unit)** | **IR (per Unit)** | **Input 1 Expected (Amps) @ 0°** | **Input 1 Test Actual (Amps)** | **Input 2 Expected (Amps) @ 180°** | **Input 2 Test Actual (Amps)** |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.47A (pickup if injecting input 1 only) | | 0.47A (pickup if injecting input 2 only) | |
| IRmin | 0.3 | 1.2 | 2.12A | | 1.65A | |
| IRs | 0.75 | 3.0 | 5.30A | | 4.12A | |
| IR>IRs | 3.25 | 8.0 | 15.11A | | 10.01A | |
| Etc. | | | | | | |

U Slope Calculations are complete. Now inject the relay according to your calculations to verify the settings and relay performance.

> NOTE:
>
> For tests which require greater than 15 A per Input (3 x Nominal Rating), be sure to maintain a short Duty Cycle to protect the relay from overheating. (i.e. short current on time, longer current off time).

**Slope Test Procedure:**

1. In Relay Control Panel, access B-PRO *Metering>Logic 3*.

   Monitor the following element for pickup:

   87B-1 High Mismatch: standalone slope characteristic without security supervision

   87B-1 Trip.

2. To test point $IR_{min}$, prepare to apply single phase current to each Input 1 and Input 2 of the B-PRO terminals as follows. Input 2 current shall be as listed in your test table.

   Input 1 current magnitude should start at Input 2 current x MCF as calculated in “B”. 1.65 A x 1.0 = 1.65 A.

   Ph A: 300 – 301, 1.65 A ∠ 0° (Input 1)

   Ph A: 306 – 307, 1.65 A ∠180°(Input 2)

3. Ramp only the Input 1 current up:

   At 2.02 A to 2.23 A (Expect 2.12 A):

Observe: Slowly ramp up the current input 1 to expect value 2.12 A from 2.02 A.

87B-1 HighMismatch = High

Pulse ramp the current directly from 2.02 A up to greater or equal to 2.12 A

87B-1 Trip = High

Out 1 = Closed

4. Test other points using the same process by presetting both currents at the lower current, then ramping one up until the 87B element operates.

End of 87B Slope Test.

**Additional Hints:**

| The Terminal Metering screens display quantities and statuses in Real Time and are useful for maintenance, troubleshooting and commissioning. |
|---|

Utilize the following various B-PRO Metering screens to monitor the relay actions:

Other metering screens which are useful in relay testing.

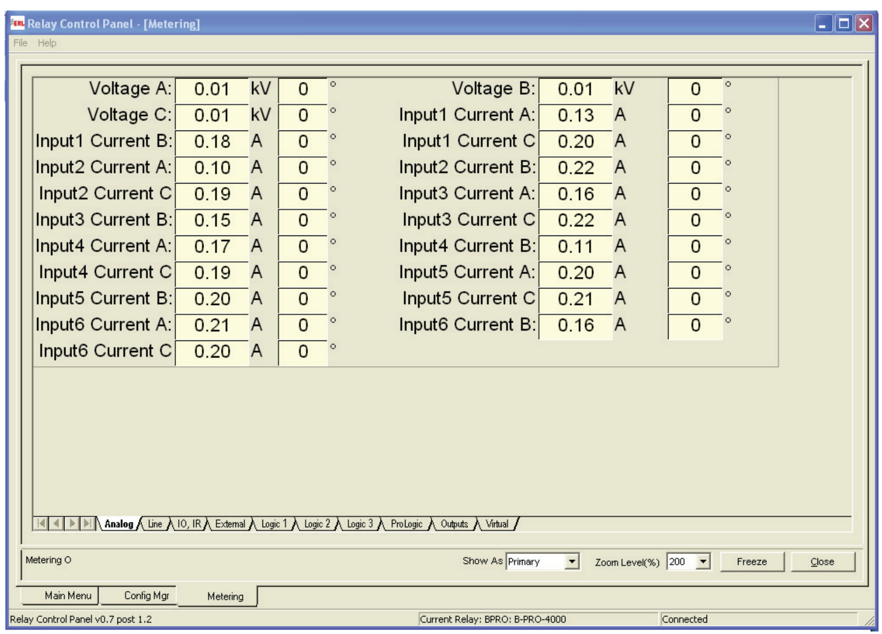



Figure 7.35: Analog Input Metering (Real Time)

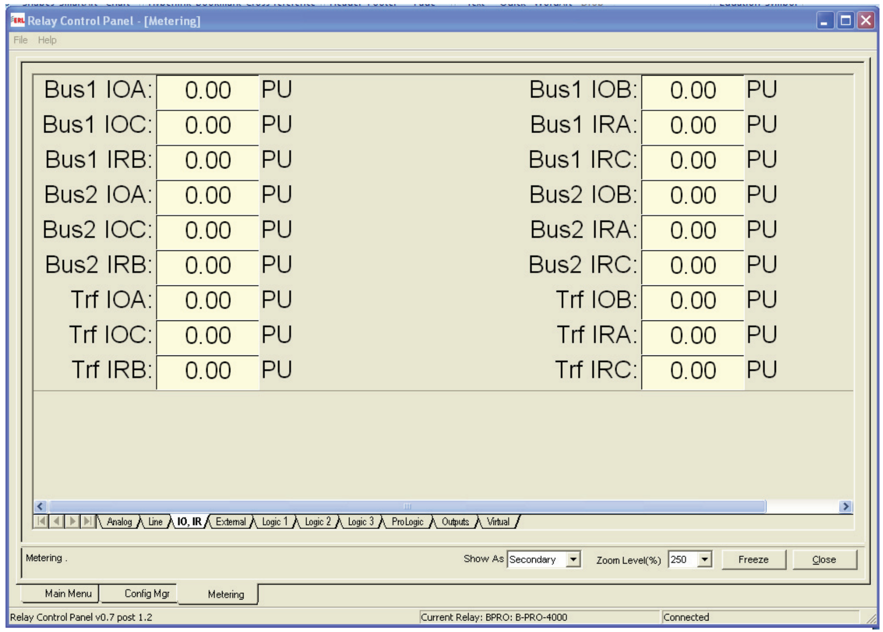



Figure 7.36: 87B-1/87B-2/87T Operating Quantities -- IO, IR Metering Tab (Real Time)

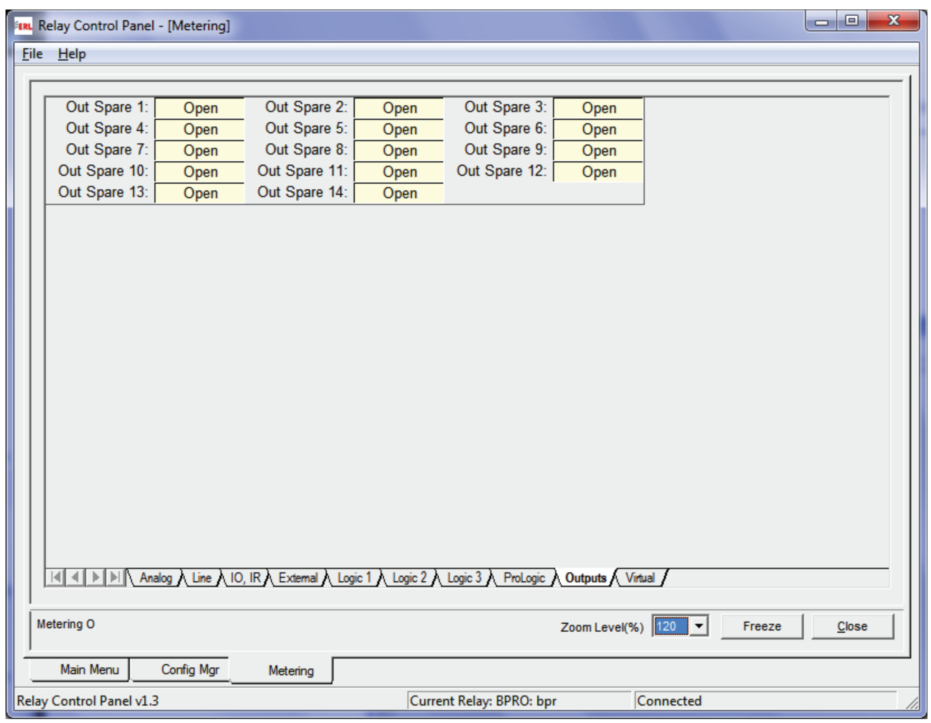



Figure 7.37: Output Contacts

# 7.5 B-PRO 87T Differential Slope Test Example

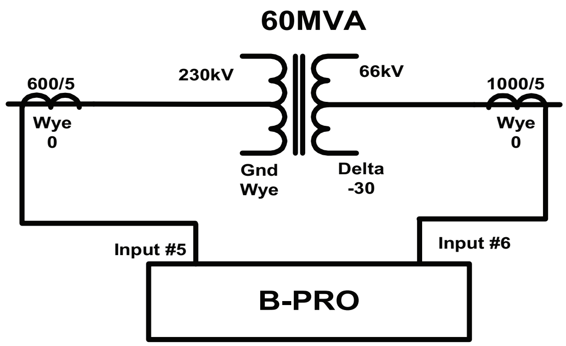



Figure 7.38: Differential Slope Test Example

## 87T Functional Test

Testing of the Transformer Differential (87T) element in the B-PRO is much the same as testing of the 87B. The basic calculations for determining the points on the 87T slope characteristic are essentially the same. However, whereas the 87B uses only wye connected current transformers (CTs), all in-phase, the 87T can have many possible wye and delta combinations of the transformer itself, as well as the CTs. Therefore, there are additional correction factors of angle and magnitude that must be taken into account in order to calculate the test currents of the 87T element.

All currents of the 87T are subject to the affects of the zero sequence elimination and current matching algorithms inside the B-PRO. See “Bus Differential Function Setting Examples” in Appendix K of the B-PRO user manual for the formulae used by the B-PRO for any transformer and CT combination.

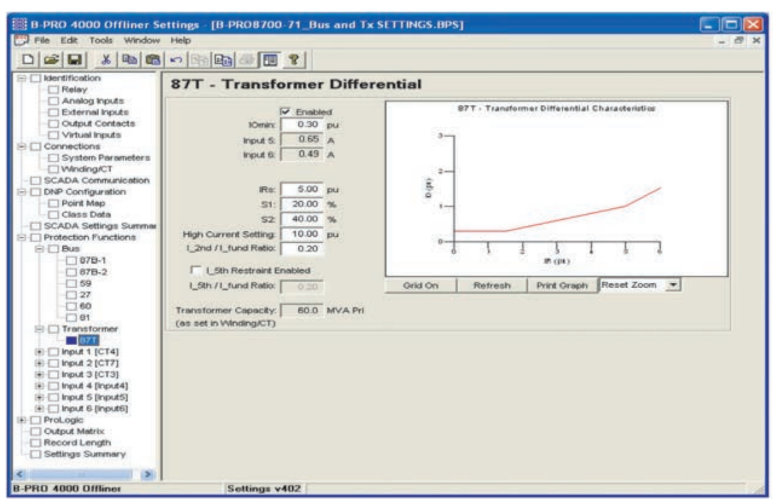



Figure 7.39: 87T Acceptance Test Settings:

### 87T Logic:

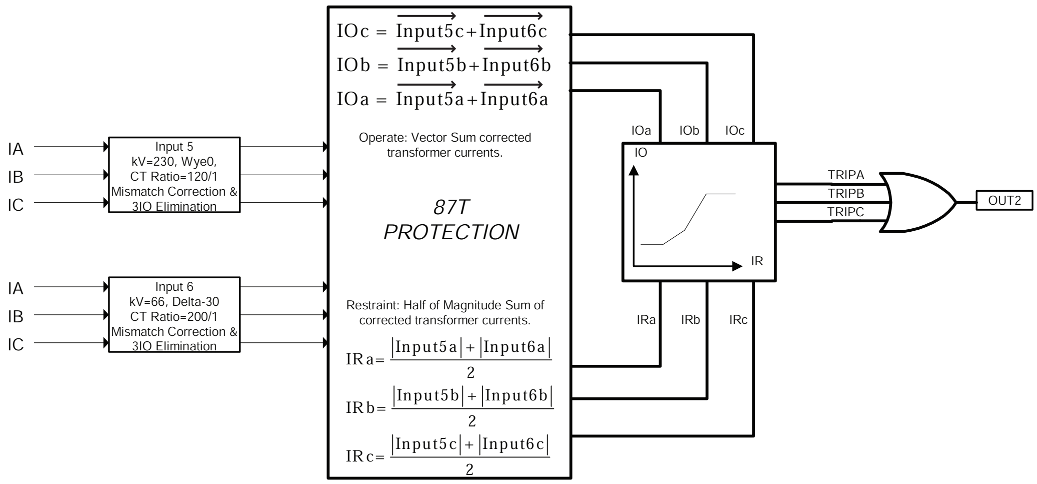



Figure 7.40: 87T Transformer Differential Functional Test Settings and Logic, Mapped to Output 2

### Summary of Procedure for B-PRO 87T Three-Phase Testing

A Create a test table to log the test results.

B Calculate base current for each transformer side.

C Calculate the $IO_{min}$ Ampere value from $IO_{min}$ per unit setting and base currents.

D Determine IO (operating) and IR (restraint) per unit values and the $I_{Input5}$ and $I_{Input6}$ Amperes for points to be tested.

E Calculate $I_{Input5}$ and $I_{Input6}$ Ampere currents for any IO and IR.

F Apply $I_{Input5}$ and $I_{Input6}$ 3-phase sources to simulate a through fault. Set the reference side at 0° and the opposite side set accordingly.

For this example the Reference Side shall be Wye side (0°).
The Delta side current angle for a through fault shall be 180° - 30° = 150° (this accounts for the -30° shift on the Delta side relative to the Wye side.)

We Begin:

**Point 1**

$IO_{min}$

A  Create a test table such as the following to document your test data:

| Point To Test | IO (per Unit) | IR (per Unit) | Input 5 Expected (Amps) @ 0° | Input 5 Actual (Amps) | Input 6 Expected (Amps) @ 150° | Input 6 Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | | | | |
| IRmin | | | | | | |
| IRs | | | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

B  Establish base load current for each transformer side:

Use the following Equations 87T Equation 1 and 87T Equation 2.

$$I_{BaseAmpsPri} = \frac{1000 \times MVA}{\sqrt{3} \times kV} \tag{21}$$

$$I_{Input5orInput6BaseAmpsSec} = I_{Input5orInput6BaseAmpsPri} \times CT_{DeltaFactor} \times \frac{1}{CTRatio}$$

Equation Note: $CT_{Delta\ factor}$ = 1.0 for Wye connected CTs, √3rd for Delta connected CTs.

Input 5 Base:

$$I_{Input5BasePri} = \frac{1000 \times MVA}{\sqrt{3} \times kV} = \frac{1000 \times 60}{\sqrt{3} \times 230} = 150.6A \tag{22}$$

$$I_{Input5BaseAmpsSec} = I_{Input5BaseAmpsPri} \times CT_{DeltaFactor} \times \frac{1}{CTRatio} \tag{23}$$

$$= 150.6 \times 1.0 \times \frac{1}{120} = 1.26A$$

Input 6 Base:

$$I_{Input6BasePri} = \frac{1000 \times MVA}{\sqrt{3} \times kV} = \frac{1000 \times 60}{\sqrt{3} \times 66} = 524.9A \tag{24}$$

$$I_{Input6BaseSec} = I_{Input6BasePri} \times CT_{DeltaFactor} \times \frac{1}{CTRatio} \tag{25}$$

$$= 524.9 \times 1.0 \times \frac{1}{320} = 1.64A$$

Z  Calculate the $IO_{min}$ current in Amperes

Calculate $IO_{min}$ for each input:

Input 5 $IO_{min}$ = 0.3 pu x 1.26 A = 0.38 A

Input 6 $IO_{min}$ = 0.3 pu x 1.64 A = 0.49 A

Enter these currents in your test table

Note, for $IO_{min}$ we inject Input 5 OR Input 6.

For the other points we inject Input 5 AND Input 6:

| **Point To Test** | **IO (per Unit)** | **IR (per Unit)** | **Input 5 Expected (Amps) @ 0°** | **Input 5 Actual (Amps)** | **Input 6 Expected (Amps) @ 150°** | **Input 6 Actual (Amps)** |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A (pickup if injecting input 5 only) | | 0.49A (pickup if injecting input 6 only) | |
| IRmin | | | | | | |
| IRs | | | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

In order to perform the Slope Test, you must define a Magnitude Correction Factor (MCF) for this transformer so that you can balance the currents as a test start point (start with 87 dropped out and then ramp one current until the 87 operates). This MCF is a ratio that be either higher IOmin secondary by the lower IOmin, or vice-versa. In this case we chose the higher IOmin by the lower IOmin: Input 6 IOmin (0.49A) by Input 5 IOmin (0.38A).

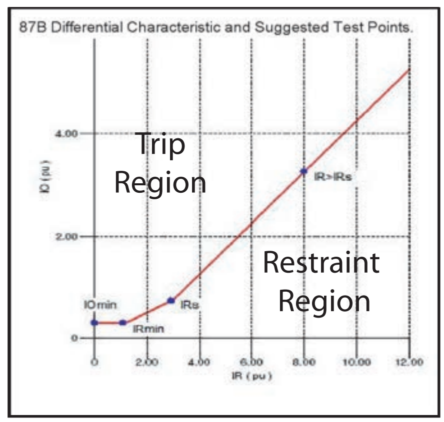
AA Calculate the Magnitude Correction Factor (MCF).

MCF is the ratio of the Input 6 $IO_{min}$ current to Input 5 $IO_{min}$ current or vice versa (values from the test table). We chose the Input 6 / Input 5 for this scenario.

$$MCF = \frac{IO_{min_{Input6}}}{IO_{min_{Input5}}} = \frac{0.49A}{0.38A} = 1.29 \tag{26}$$

AA IO and IR for $IR_{min}$ (Point 2 of the characteristic). We use a similar process as we used for the 87B element.

The graph at the right shows some typical points which may be tested to prove the slope characteristic. Method to calculate the required test currents shall follow.




Determine the IO and IR current values on the 87T slope (through-fault restraint characteristic) where the B-PRO 87T element will operate. You can determine the current pickup values of current for any values of IO and IR on the curve.

The following equations for operate and restraint current (87T Equation 3 and 87T Equation 4) will be used to determine the test currents for the 87 Slope characteristic:

$$IO = \lceil Input5 \rceil + \lceil Input6 \rceil \tag{28}$$

OR for an ideal through fault:

$$IO = |I_{Input5}| - |I_{Input6}| \tag{29}$$

$$IR = \frac{|I_{Input5}| + |I_{Input6}|}{2} \tag{30}$$

**Point 2**

Calculate currents to test IR = $IR_{min}$ (Restraint Current at Slope 1 start)

$$IO = \frac{S1 \times IR}{100} \tag{31}$$

$$0.3 = \frac{25 \times IR_{min}}{100}$$

Isolate $IR_{min}$

$$IR_{min} = \frac{30}{25} = 1.20pu \tag{32}$$

Note: at IR = $IR_{min}$. IO = $IO_{min}$ = 0.3pu

Therefore if $IO_{min}$ = 0.3 per unit and Slope 1 = 25%, then $IR_{min}$ = 1.2 per unit.

Enter the IO and IR points into your test table.

| Point To Test | IO (per Unit) | IR (per Unit) | Input 5 Expected (Amps) @ 0° | Input 5 Actual (Amps) | Input 6 Expected (Amps) @ 150° | Input 6 Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A | | 0.49A | |
| IRmin | 0.3 | 1.2 | | | | |
| IRs | | | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

Solve for Input 5 and Input 6 test currents to give:

IO = 0.3 pu

$IR_{min}$ = 1.2 pu

Use above 87T Equation 3 and 87T Equation 4 to solve for test currents.

Isolate $I_{Input5}$ and $I_{Input6}$ on the right side of the IO and IR equations:

$$IO = |I_{Input5}| - |I_{Input6}| \quad (33)$$

$$0.3 = |I_{Input5}| - |I_{Input6}|$$

$$IR = \frac{|I_{Input5}| - |I_{Input6}|}{2} \quad (34)$$

$$1.2 = \frac{|I_{Input5}| - |I_{Input6}|}{2}$$

$$1.2 \times 2 = |I_{Input5}| + |I_{Input6}|$$

$$2.4 = |I_{Input5}| + |I_{Input6}|$$

Add and subtract the two above equations find $I_{Input5}$ and $I_{Input6}$ to determine the currents required to operate the 87B element.

Solve for $I_{Input5}$ by adding the two equations together:

$$0.3 = |I_{Input5}| - |I_{Input6}|$$

$$+2.4 = |I_{Input5}| + |I_{Input6}|$$

$$\text{Total} = 2.7 = 2|I_{Input5}| + 0|I_{Input6}|$$

$$\frac{2.7}{2} = |I_{Input5}| = 1.35pu$$

$$I_{Input5_{Amps}} = I_{Input5BaseSec} \times I_{Input5_{perUnit}} = 1.26A \times 1.35pu = 1.69A \quad (35)$$

Solve for $I_{Input6}$ by subtracting the two equations:

$$0.3 = |I_{Input5}| - |I_{Input6}|$$

$$-2.4 = |I_{Input5}| + |I_{Input6}|$$

$$\text{Total} = -2.1 = 2|I_{Input5}| - 2|I_{Input6}|$$

$$\frac{-2.1}{-2} = |I_{Input6}| = 1.05pu$$

$$I_{Input6_{Amps}} = I_{Input6BaseSec} \times I_{Input6_{pu}} = 1.64A \times 1.05pu = 1.72A$$

Enter the Input 5 and Input 6 test currents into your test table.

| Point To Test | IO (per Unit) | IR (per Unit) | Input 5 Expected (Amps) @ 0° | Input 5 Actual (Amps) | Input 6 Expected (Amps) @ 150° | Input 6 Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A | | 0.49A | |
| IRmin | 0.3 | 1.2 | 1.69A | | 1.72A | |
| IRs | | | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

**Point 3**

Calculate test currents for IR = IRs = 3.0 per unit.

The next point to calculate is currents at IR = IRs. This is the point on the 87 characteristic where Slope 1 ends and the Slope 2 begins. Use above 87T Equation 5 to get IO per unit at IRs.

$$IO = \frac{S1 \times IR}{100} \tag{36}$$

$$IO = \frac{25 \times 3.0}{100} = \frac{75}{100}$$

$$IO = 0.75pu$$

Enter the IO and IR points into your test table.

| Point To Test | IO (per Unit) | IR (per Unit) | Input 5 Expected (Amps) @ 0° | Input 5 Actual (Amps) | Input 6 Expected (Amps) @ 150° | Input 6 Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A | | 0.49A | |
| IRmin | 0.3 | 1.2 | 1.69A | | 1.72A | |
| IRs | 0.75 | 3.0 | | | | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

Solve for Input 5 and Input 6 test currents to give:

IO = 0.75 pu

IRs = 3.0 pu

Use above 87T Equation 3 and 87T Equation” to solve for test currents.

Isolate $I_{Input5}$ and $I_{Input6}$ on the right side of the IO and IR equations:

$$IO = |I_{Input5}| - |I_{Input6}| \tag{37}$$

$$0.75 = |I_{Input5}| - |I_{Input6}|$$

$$IR = \frac{|I_{Input5}| + |I_{Input6}|}{2} \tag{38}$$

$$3.0 = \frac{|I_{Input5}| + |I_{Input6}|}{2}$$

$$3.0 \times 2 = |I_{Input5}| + |I_{Input6}|$$

$$6.0 = |I_{Input5}| + |I_{Input6}|$$

Add and subtract the two above equations find $I_{Input5}$ and $I_{Input6}$ to determine the currents required to operate the 87B element.

Solve for $I_{Input5}$ by adding the two equations together:

$$0.75 = |I_{Input5}| - |I_{Input6}|$$

$$+6.0 = |I_{Input5}| - |I_{Input6}|$$

$$\text{Total} = 6.75 = 2|I_{Input5}| + 0|I_{Input6}|$$

$$\frac{6.75}{2} = |I_{Input5}| = 3.375pu$$

$$I_{Input5_{Amps}} = I_{Input5BaseSec} \times I_{Input5_{pu}} = 1.26A \times 3.375pu = 4.25A \tag{39}$$

Solve for $I_{Input6}$ by subtracting the two equations:

$$0.75 = |I_{Input5}| - |I_{Input6}|$$

$$-6.0 = |I_{Input5}| + |I_{Input6}|$$

$$\text{Total} = -5.25 = 0|I_{Input5}| - 2|I_{Input6}|$$

$$\frac{-5.25}{-2} = |I_{Input6}| = 2.625pu$$

$$I_{Input6_{Amps}} = I_{Input6BaseSec} \times I_{Input6_{pu}} = 1.64A \times 2.625pu = 4.31A$$

Enter the Input 5 and Input 6 test currents into your test table.

| Point To Test | IO (per Unit) | IR (per Unit) | Input 5 Expected (Amps) @ 0° | Input 5 Actual (Amps) | Input 6 Expected (Amps) @ 150° | Input 6 Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A | | 0.49A | |
| IRmin | 0.3 | 1.2 | 1.69A | | 1.72A | |
| IRs | 0.75 | 3.0 | 4.25A | | 4.31A | |
| IR>IRs | | | | | | |
| Etc. | | | | | | |

**Point 4**

Testing of IR > IRs

The next point to calculate are the currents at some point of IR > IRs. This is a point on the 87 Slope 2.

**Calculate Currents to Test IR > IRs (Let IR = 8.0 pu)**

First, calculate the value of IO at IR of 8.0 using the following 87T Equation 6.

$$IO = \frac{50 \times 8.0}{100} + \frac{25 - 50}{100} \times 3.0 \tag{40}$$

$$IO = 4.0 + \langle -0.75 \rangle$$

$$IO = 3.25pu$$

Therefore with Slope 1 = 25% and Slope 2 = 50%, if IR = 8.0 per unit then IO = 3.25 per unit.

Enter the IO and IR points into your test table.

| Point To Test | IO (per Unit) | IR (per Unit) | Input 5 Expected (Amps) @ 0° | Input 5 Actual (Amps) | Input 6 Expected (Amps) @ 150° | Input 6 Actual (Amps) |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A | | 0.49A | |
| IRmin | 0.3 | 1.2 | 1.69A | | 1.72A | |
| IRs | 0.75 | 3.0 | 4.25A | | 4.31A | |
| IR>IRs | 3.25 | 8.0 | | | | |
| Etc. | | | | | | |

Solve for Input 5 current and Input 6 current to give:

IO = 3.25 pu

IR = 8.0 pu

Use above 87T Equation 3 and 87T Equation 4 to solve for test currents.

Isolate $I_{Input5}$ and $I_{Input6}$ on the right side of the IO and IR equations:

$$IO = |I_{Input5}| - |I_{Input6}| \tag{41}$$

$$3.25 = |I_{Input5}| - |I_{Input6}|$$

$$IR = \frac{|I_{Input6}| + |I_{Input6}|}{2} \tag{42}$$

$$8.0 = \frac{|I_{Input6}| + |I_{Input6}|}{2}$$

$$16.0 = |I_{Input5}| + |I_{Input6}|$$

Add and subtract the two above equations find $I_{Input5}$ and $I_{Input6}$ to determine the currents required to operate the 87B element.

Solve for $I_{Input5}$ by adding the two equations together:

$$3.25 = |I_{Input5}| - |I_{Input6}|$$

$$+16.0 = |I_{Input5}| + |I_{Input6}|$$

$$\text{Total} = 19.25 = 2|I_{Input5}| + 0|I_{Input6}|$$

$$\frac{19.25}{2} = |I_{Input5}| = 9.625pu$$

$$I_{Input5_{Amps}} = I_{Input5BaseAmps} \times I_{Input5_{pu}} = 1.26A \times 9.625pu = 12.13A$$

Solve for $I_{Input6}$ by subtracting the two equations:

$$3.25 = |I_{Input5}| - |I_{Input6}|$$

$$-16.0 = |I_{Input5}| + |I_{Input6}|$$

$$\text{Total} = -12.75 = 0|I_{Input5}| - 2|I_{Input6}|$$

$$\frac{-12.75}{-2} = |I_{Input6}| = 6.375pu$$

$$I_{Input6_{Amps}} = I_{Input6BaseSec} \times I_{Input6_{pu}} = 1.64A \times 6.375pu = 10.46A$$

Enter the Input 5 and Input 6 test currents into your test table.

| **Point To Test** | **IO (per Unit)** | **IR (per Unit)** | **Input 5 Expected (Amps) @ 0°** | **Input 5 Actual (Amps)** | **Input 6 Expected (Amps) @ 150°** | **Input 6 Actual (Amps)** |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A | | 0.49A | |
| IRmin | 0.3 | 1.2 | 1.69A | | 1.72A | |
| IRs | 0.75 | 3.0 | 4.25A | | 4.31A | |
| IR>IRs | 3.25 | 8.0 | 12.13A | | 10.46A | |
| Etc. | | | | | | |

AQ Slope calculations are complete. Now inject the relay according to your calculations to verify the settings and relay performance.

## Test the $IR_{min}$ Point

1. In Relay Control Panel, access B-PRO *Metering>logic>protection>logic 2*. Monitor the following element for pickup: 87T Trip

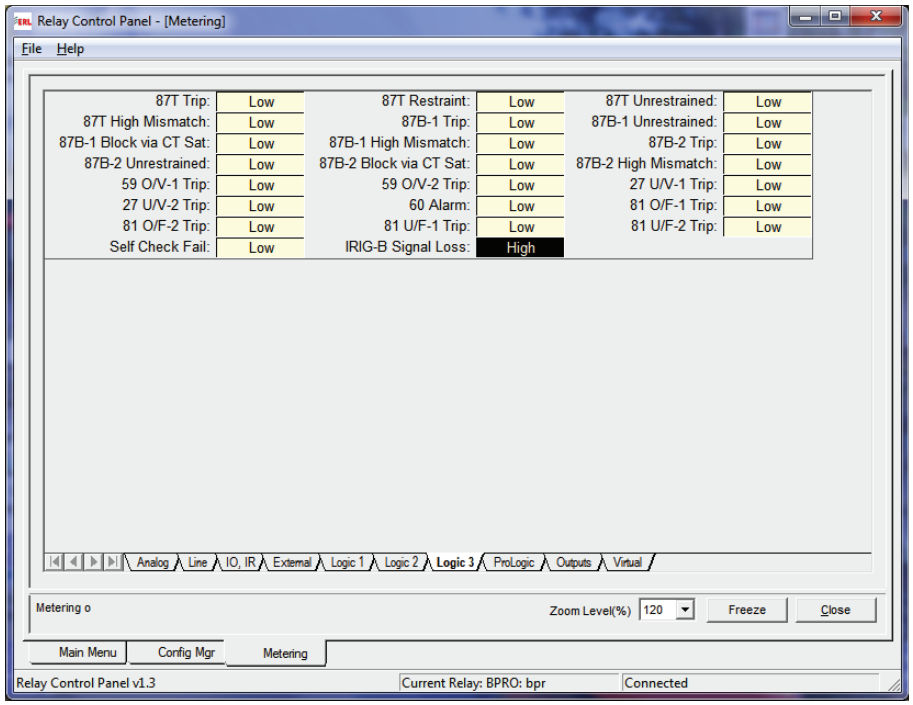



Figure 7.41: Metering Logic 3 (Protection)

2. Prepare to apply 3 phase currents to the B-PRO terminals as follows:

   The Input 6 preset current as per calculation in above “D” = 1.72 A

   The Input 5 preset current = Input 6 preset current / MCF = 1.72 A /1.29 = 1.33 A

   Note: MCF was calculated in “B” above.

   Note: These preset currents represent the balance point of the element.)

   Input 5:

   Ph A: 324 – 325, 1.33A ∠0°

   Ph B: 326 – 327, 1.33A ∠ -120°

   Ph C: 328 – 329, 1.33A ∠+120°

   Input 6:

   Ph A: 330 – 331, 1.72A ∠ +150°

   Ph B: 332 – 333, 1.72A ∠ +30°

   Ph C: 334 – 335, 1.72A ∠ -90°

3. Ramp all 3-phase Input 5 currents up:
   At 1.61 A to 1.77 A (expect 1.69 A):
   Observe: 87T Trip = High
   Out2 = Closed
4. B-PRO Target: “87T Trip on ABC”.
5. Repeat the process for other slope points.

End of 87T Minimum Operate Test.

NOTE: For tests which require greater then 15 A per input (3x Nominal Rating), maintain a short duty cycle to protect the relay from overheating.

# 7.6 B-PRO 87T SIngle Phase Slope Test

## Summary of Steps to Perform Single Phase Testing

A Create a test table similar to the one used in the 3-phase test.

B Perform the current calculations for 3-phase testing as per the previous section (i.e. IO, IR, $I_{input5}$ , $I_{input6}$ ).

C Determine the natural current phase shift into each of the current inputs of the B-PRO 87T.

D Determine the compensating angle required to Null the current shift.

E Determine which phase(s) to inject on each side. For this example, we will always inject so that the relay will see A-B, B-C or C-A (assuming ABC phase rotation). We demonstrate only A-B here but testing the other phases is a simple matter of rotating your test connections.

F Apply the additional Single Phase Magnitude Correction Factor to the calculated 3-phase test currents (we call this “SPF5” for input 5, and “SPF6” for input 6.

HINT:

To confirm your calculations, it's helpful to monitor Metering>analog>87t Operating values in the B-PRO relay (shown below).

This screen shows the Operating and Restraint magnitudes that the B-PRO uses for 87T differential calculations (after performing CT matching and phase shift manipulations).

If you have performed the calculations correctly, this screen can verify the IO and IR values.

**Metering>Analog>87T Operating:**

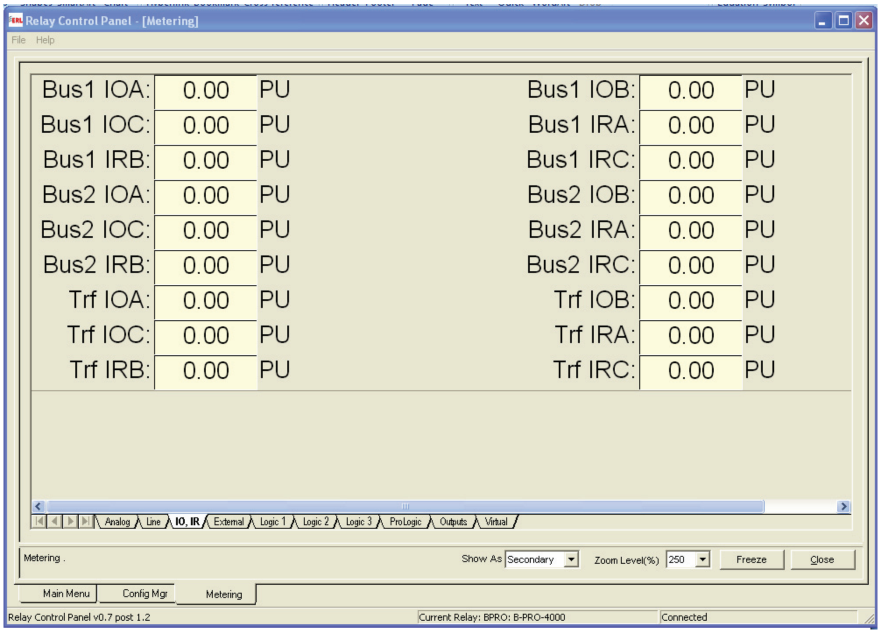



Figure 7.42: 87B-1/87B-2/87T Operating Quantities -- IO, IR Metering Tab (Real Time)

# 7.7 87T Single Phase Test Example

A Steps to perform single phase testing of the B-PRO 87T

Create your test table and copy the IO and IR values from the 3-phase test table.

Note: For single-phase slope testing with the method demonstrated here currents will always be at 0° and 180°.

| **Point To Test** | **IO (per Unit)** | **IR (per Unit)** | **Input 5 Expected (Amps) @ 0°** | **Input 5 Actual (Amps)** | **Input 6 Expected (Amps) @ 180°** | **Input 6 Actual (Amps)** |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A x SPF5 | | 0.49A x SPF6 | |
| IRmin | 0.3 | 1.2 | 1.69A x SPF5 | | 1.72A x SPF6 | |
| IRs | 0.75 | 3.0 | 4.25A x SPF5 | | 4.31A x SPF6 | |
| IR>IRs | 3.25 | 8.0 | 12.13A x SPF5 | | 10.46A x SPF6 | |
| Etc. | | | | | | |

B Determine the net phase shift for each transformer side.

Input 5 Shift = Input 5 Transformer Shift + Input 5 CT Shift

= 0° + 0° = 0°

Input 6 Shift = Input 6 Transformer Shift + Input 6 CT Shift

= -30° + 0° = -30°

C Determine the Phase Shift Compensation Angle see “Analog Phase Shift Table” in Appendix M.

Input 5 compensation requires 0° shift to null the 0° angle.

Input 6 compensation requires + 30° shift to null the -30° angle.

D Determine the phases to inject from “87T Single-Phase Connection Diagrams For Phases A-B” on page 7.-63.

For this case, Input 5 is the 0° connection and Input 6 is the +30° connection.

Below are the test connections and current angles to simulate a through fault on phases A-B.

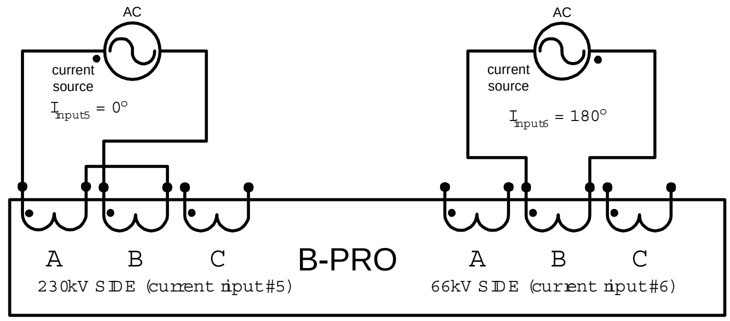



Figure 7.43:

E Determine the Input 5 and Input 6 additional correction factors (SPF) for Single Phase Testing.

From “87T Single-Phase Connection Diagrams For Phases A-B” on page 7.-63 we find:

Input 5 SPF = 1.0

Input 6 SPF = √3

Apply the appropriate SPF to each input’s 3-phase test currents.

| **Point To Test** | **IO (per Unit)** | **IR (per Unit)** | **Input 5 Expected (Amps) @ 0°** | **Input 5 Actual (Amps)** | **Input 6 Expected (Amps) @ 180°** | **Input 6 Actual (Amps)** |
|---|---|---|---|---|---|---|
| IOmin | 0.3 | 0.15 | 0.38A x 1.0 = **0.38A** | | 0.49A x √3 **= 0.849A** | |
| IRmin | 0.3 | 1.2 | 1.69A x 1.0 = **1.69A** | | 1.72A x √3 **= 2.98A** | |
| IRs | 0.75 | 3.0 | 4.25A x 1.0 = **4.25A** | | 4.31A x √3 **= 7.47A** | |
| IR>IRs | 3.25 | 8.0 | 12.13A x 1.0 = **12.13A** | | 10.46A x √3 = **18.12A** | |
| Etc. | | | | | | |

Calculate the Magnitude Correction Factor (MCF).

MCF is the ratio of the Input 6 $IO_{min}$ current to Input 5 $IO_{min}$ current or vice versa (values from the test table). We chose the Input 6 / Input 5 for this scenario.

$$MCF = \frac{IOmin_{Input6}}{IOmin_{Input5}} = \frac{0.849A}{0.38A} = 2.23 \qquad (6)$$

## IR$_{min}$ Test Procedure

1. In Relay Control Panel, access B-PRO *Metering>Logic>Protection>Logic 2.*

   Monitor the following element for pickup: 87T Trip.

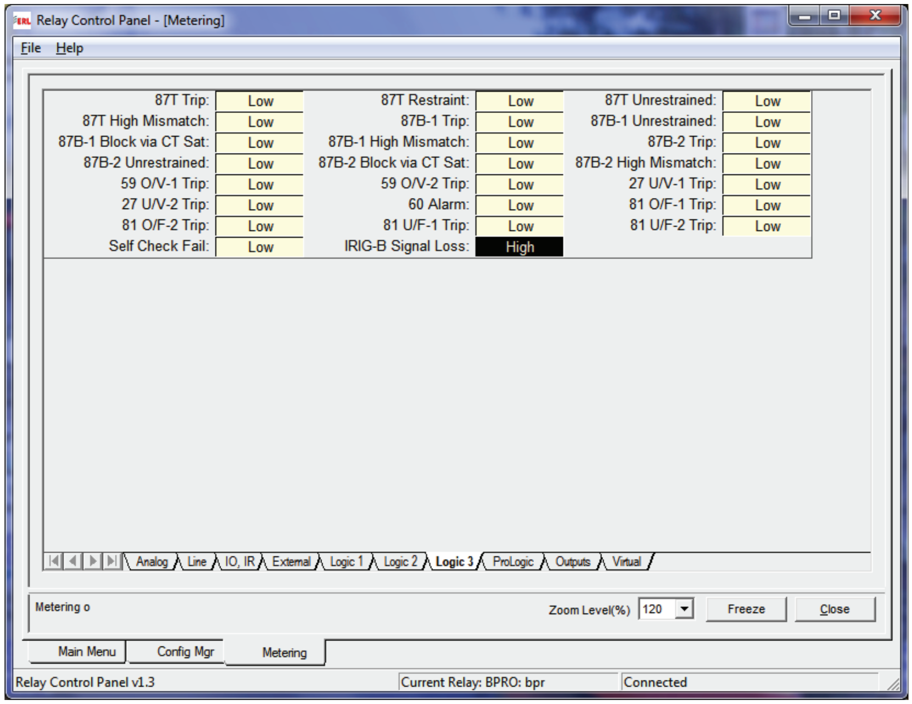



Figure 7.44: Metering Logic 3 (Protection)

2. Prepare to apply 3-phase currents to the B-PRO terminals as follows:

   Input 6 preset current as per point 2 calculation in above “E” = 2.98 A

   Input 5 preset current = Input 6 preset current / MCF = 2.98 A / 2.23 = 1.33 A

   Note: MCF was calculated in “F” above.)

   (Note: These preset currents represent the balance point.)

   Source 1, Input 5:

   Ph A-B: 324 – 326 (jumper 325 – 327), 1.33 A ∠ 0°

   Source 2, Input 6:

   Ph B: 333 – 332, 2.98A ∠ 180°

3. Ramp source 1 (Input 5) current up:

   At 1.61 A to 1.77 A (expect 1.69 A):

   Observe: 87T Trip = High

   Out2 = Closed

4. B-PRO Target: “87T Trip on AB”

5. Repeat the process for other slope points you have selected.

End of 87T IR$_{min}$ test.

HINT:

For any single-phase or other unbalanced currents that you inject, the B-PRO should be used to determine how the currents will be manipulated in the relay and where they will appear on the 87T IO / IR characteristic.

## Testing 87 2nd Harmonic Restraint

**Settings:**

I2 (2nd Harmonic) = 0.20 per unit (2nd Harmonic restrains if 20% of fundamental current)

**2nd Harmonic Restraint Test Procedure:**

1. In Relay Control Panel access B-PRO *Metering>Logic*.
   Monitor the following elements for pickup:
   87T Trip
   87 Restraint
2. Apply paralleled currents to terminals 324 – 325 as follows:
   Source 1 (Fundamental): 4.0 A ∠ 0° (Terminals 324 – 325)
   Source 2 (2nd Harmonic): 1.2 A ∠ 0° (also Terminals 324 – 325)
   Observe:87T Trip = Low
   87T Restraint = High
3. Slowly ramp down source 2 current,
   At 0.76 A to 0.84 A (Expect 0.80 A), 87T Trip = High
   87T Restraint = Low

End of 2nd harmonic restraint test.

## Testing 87 High Current Setting

**Settings:**

High Current Setting = 8.0 per unit

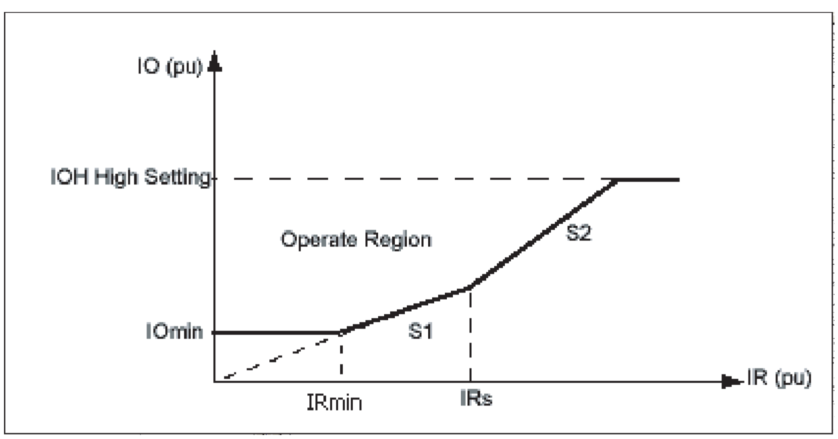



Figure 7.45: High Current Setting

**87T High Current Test Procedure:**

1. In Relay Control Panel access B-PRO Metering>Logic.
   Monitor the following elements for pickup:
   87T Trip
   87TRestraint
   87T Unrestrained
2. Apply paralleled currents to terminals 324 – 325 as follows:
   Source 1 (Fundamental frequency):9.5 A ∠ 0° (Terminals 324 – 325)
   Source 2 (2nd Harmonic): 3.00 A ∠ 0° (also Terminals 324 – 325)
   Observe: 87T Trip = Low
   87T Restraint = High
   87T FastTrip = Low
3. Ramp source 1 up:
   At 9.6 to 10.6 Amps (expect 10.1 A):
   87T Trip = High
   87T Restraint = Low
   87T FastTrip = High

Note: This test proves that when the high current setting is exceeded, 2nd Harmonic has no restraint affect. The 87T high current (Unrestrained) element is always unrestrained.)

4. Remove test currents.

End of High Current Setting Test.

**87B CT Saturation Algorithm Test:**

ERLPhase recommends dynamic test equipment for testing of the CT Saturation Blocking Algorithm.

The B-PRO Setting and Test Spreadsheet Tool can be utilized to obtain COMTRADE test files.

The B-PRO Setting and Test Spreadsheet Tool can also be utilized to obtain the Slope and Overcurrent test quantities.

## 27 Functional Test

In this example we demonstrate the testing of 27-2, but testing 27-1 is just a matter of enabling the function and reducing only one phase voltage.

### 27 Functional Test Settings

Go to Relay Control Panel configuration, select *87B* --> *device (under-voltage)* and *Enable* and set 27 to;

Gate Switch = *OR*.

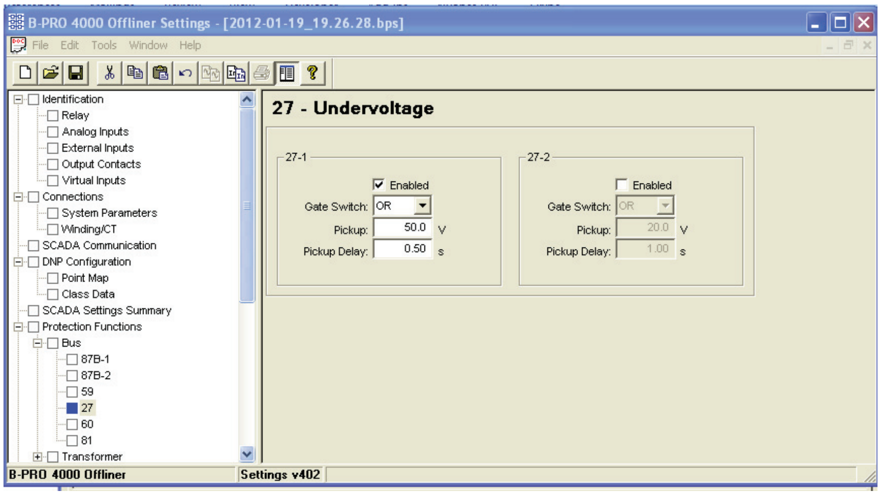



Figure 7.46: Setting Device 27-1

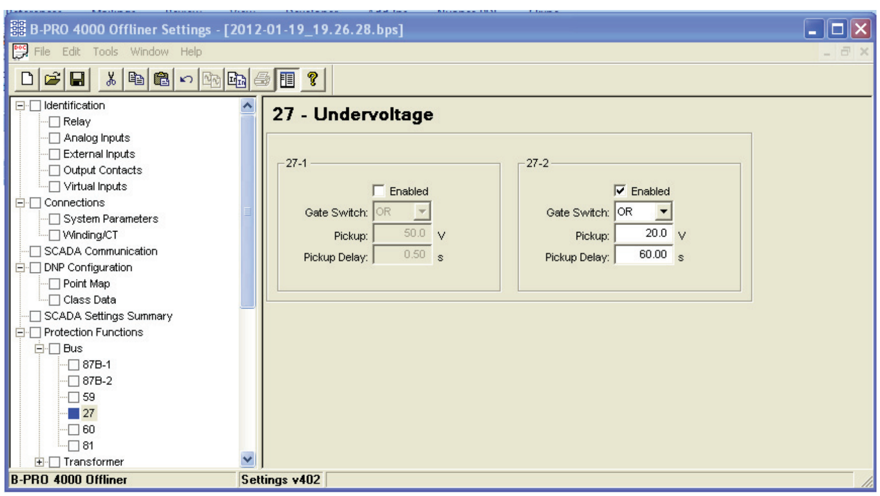



Figure 7.47: Setting Device 27-2

Alternately, you may change the settings in the B-PRO *Offliner* Acceptance Test file and upload to the relay.

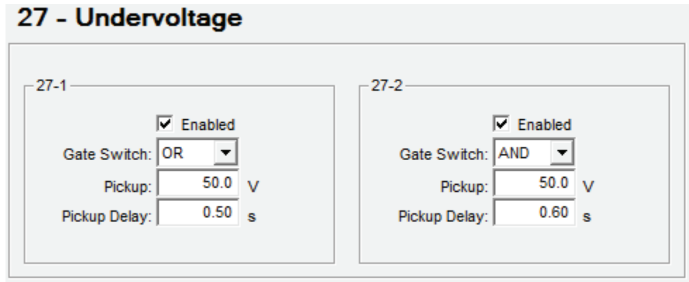



Figure 7.48: 27 Undervoltage

## 27 Single-Phase Functional Test Logic

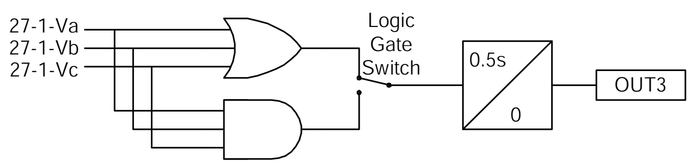



Figure 7.49: 27-1 Undervoltage Functional Test Settings and Logic, Mapped to Output 3

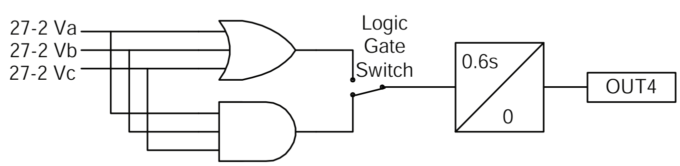



Figure 7.50: 27-2 Undervoltage Functional Test Settings and Logic, Mapped to Output 4

## 27 3-Phase UnderVoltage Test Procedure

1. In Relay Control Panel, access B-PRO *Metering>Logic.*
   Monitor the following element for pickup: 27-2 Trip

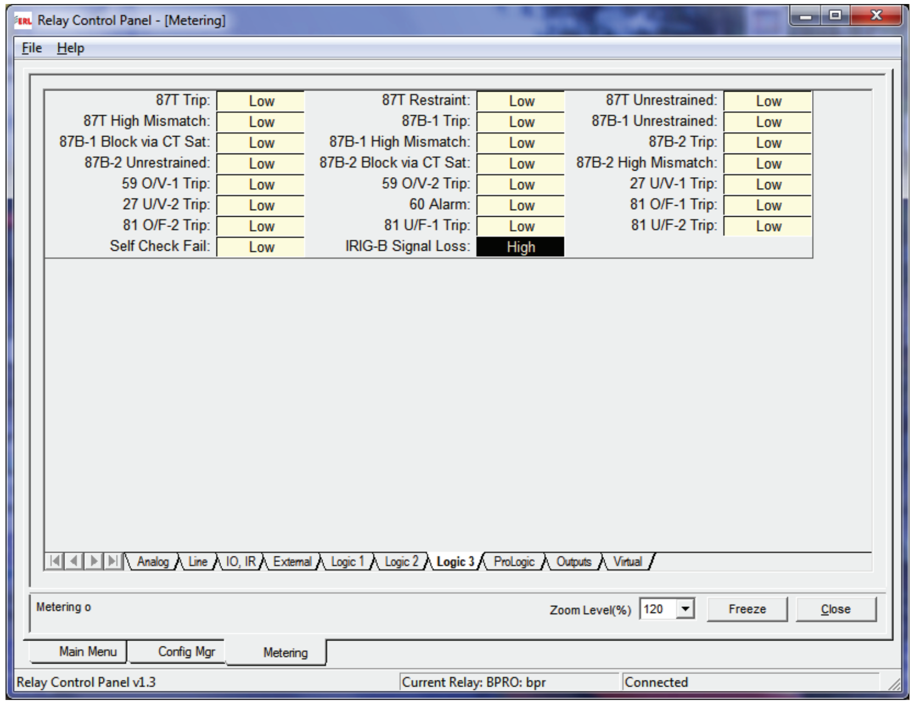



Figure 7.51: Metering Logic 3 (Protection)

2. Apply balanced 3-phase voltages to the B-PRO terminals as follows:
   Ph A: 230, 66.4V ∠ 0 °
   Ph B: 231, 66.4V ∠ -120 °
   Ph C: 232, 66.4V ∠ 120 °
   Ph N: 233
3. Slowly ramp the 3-phase voltage magnitudes down.
   At 50.5 to 49.5 V per phase (expect 50.0).
   Observe: 27-2 Trip = High
   Out 3 = Closed
   Out 4 = Closed
4. Turn voltages off.

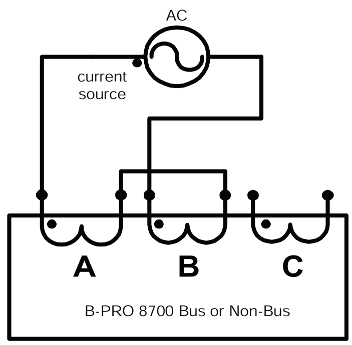
End of 27 test.

# 7.8 87T Single-Phase Connection Diagrams For Phases A-B

### ABC Phase Rotation Relays

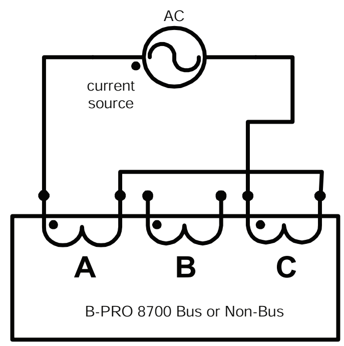
Please Observe Polarities (dot) Shown for Current Source Output and Relay Inputs.

**0˚ Connection**



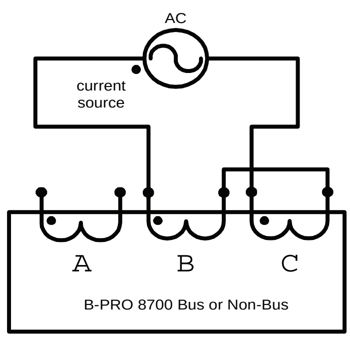

87T Single Phase Correction Factor = 1.0

**+60˚ Connection**



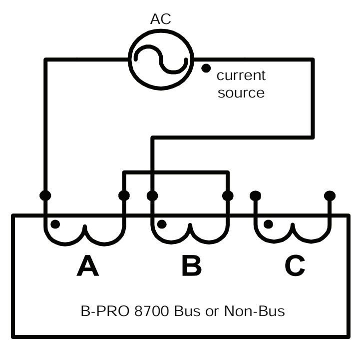

87T Single Phase Correction Factor = 1.0

+120 Connection



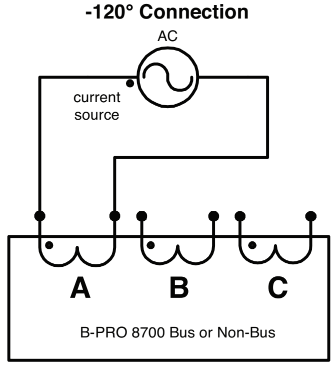

87T Single Phase Correction Factor = 1.0

**180˚ Connection**



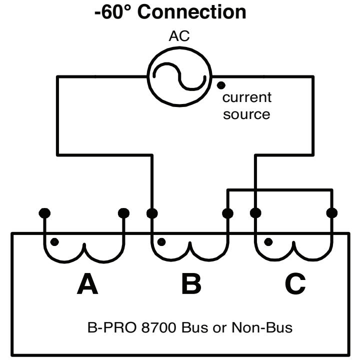

87T SinglePhase Correction Factor = 1.0

**-120° Connection**



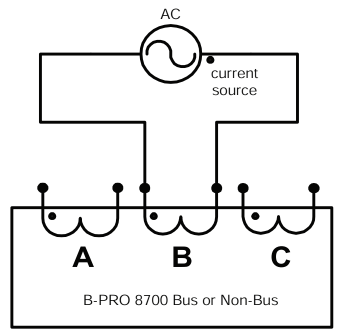

87T Single Phase Correction Factor = 1.0

**-60° Connection**



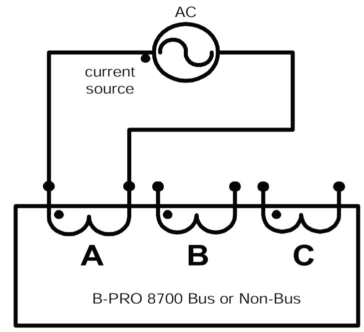

87T Single Phase Correction Factor = 1.0

**-30˚ Connection**



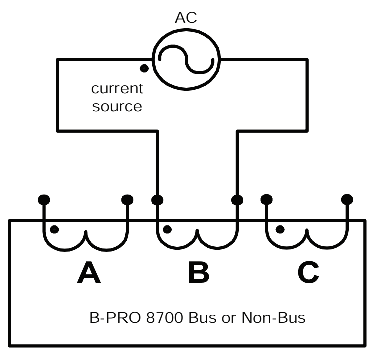

87T Single Phase Correction Factor = 3

**+90˚ Connection**



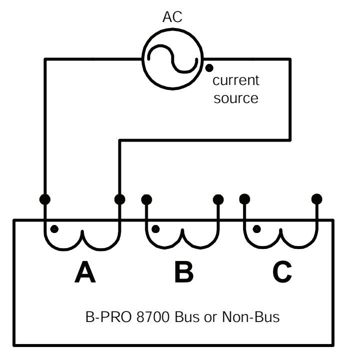

87T Single Phase Correction Factor = √3

**+150˚ Connection**



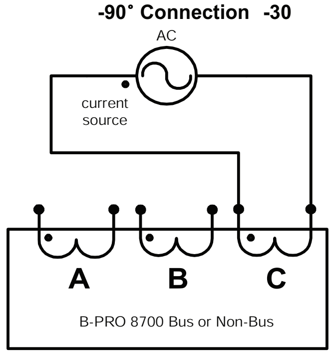

87T Single Phase Correction Factor= √3

**-150˚ Connection**



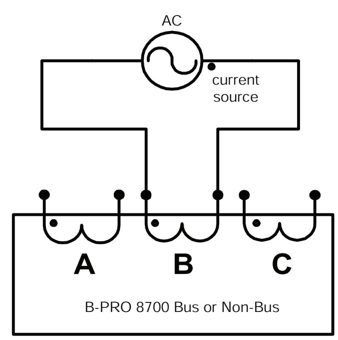

87T Single Phase Correction Factor = √3

**-90˚ Connection -30**




87T Single Phase Correction Factor = √3

**-30˚ Connection**




87T Single Phase Correction Factor = 3

# 8. Installation

## 8.1 Introduction

This section deals with the installation of the B-PRO relay when first delivered. The section covers the physical mounting, AC and DC wiring and the Communication wiring.

## 8.2 Physical Mounting

### Standard 3U

The relay is 3 rack units or 5.25 inches high and approximately 12.9 inches deep. The standard relay is designed for a 19-inch rack. A complete mechanical drawing is shown, for details see “Mechanical Drawings” in Appendix G.

To install the relay the following is needed:

- 19 inch rack
- 4 - #10 screws

## 8.3 AC and DC Wiring

For details see “AC Schematic Drawing” in Appendix I and “DC Schematic Drawing” in Appendix J.

## 8.4 Communication Wiring

### EIA-232

The relay’s serial ports (Ports 122 and 123) are configured as EIA RS-232 Data Communications Equipment (DCE) devices with female DB9 connectors. This allows them to be connected directly to a PC serial port with a standard straight-through male-to-female serial cable. Shielded cable is recommended, for pin-out details see “Communication Port Details” on page 2-17.

An adapter is available for connecting an external modem to Port 123 for details, “Modem Link” on page 2-9.

### RJ-45

There are two 100BASE-T Ethernet interfaces labelled Ports 119 (one front and one rear panel) with RJ 45 receptacle. Use CAT5 or CAT5e straight through cable.

### Optical ST

Port 120 in the rear panel of the relay has ST style optical connectors. Port 119 in the rear panel may also be configured with ST style optical connectors if desired. These are 1300nm 100BASE-FX optical Ethernet ports. The transmit and receive connections are indicated on the rear panel. Use standard multimode cables with ST connectors for this interface.

## USB

There is a standard USB-B connector on the front panel. This is a USB 2.0 Full Speed interface and can be connected to a PC with a standard USB peripheral cable (A style to B style).

## RJ-11

The relay may have an optional internal modem. Connection to this is via the relay's Port 118 RJ-11 receptacle. A standard telephone extension cable is to be used.

## IRIG-B Wiring

The relay accepts both modulated and unmodulated IRIG-B standard time signals with or without the IEEE 1344 extensions. The IRIG-B connector on the back of the relay is BNC type.

# Appendix A IED Specifications

| Table A.9: B-PRO Model 4000 Specification | | |
|---|---|---|
| **Item** | **Quantity/Specs** | **Notes** |
| **General:** | | |
| Nominal Frequency | 50 or 60 Hz | |
| Operate Time | 87B: 16 – 25 ms typical<br>87T: 12 – 24 ms typical | Including relay output operation |
| Sampling Rate - Analog and digital inputs | 96 samples/cycle for recording<br>8 samples/cycle for protection | Records up to the 25th harmonic |
| Sampling Resolution | Amplitude measurement accuracy: +/- 0.5% for 54 to 66 Hz | |
| Power Supply | Nominal Range: 43 – 275 Vdc, 90 – 265 Vac, 50/60 Hz<br>Full Operating Range: 40 – 300 Vdc | Power Consumption: 25 – 35 VA (ac)<br>25 – 35 W (dc) |
| Memory | Settings and records are stored in non-volatile memory | Records are stored in a circular buffer |
| **Protection Functions:** | | |
| IEEE Dev. 87B, 59, 27, 60, 81, 87T, 50LS, 50BF, 50/51/67, 50N/51N/67, 46-50/46-51/67 | 6 x 3-phase current inputs (18 current channels)<br>1 x 3-phase voltage inputs (3 voltage channels) | Fault protection, monitoring and dynamic swing recording |
| ProLogic | 15 statements/setting group | 5 inputs/statement |
| **Recording:** | | |
| Record Capacity | Up to 75 x 2 second transient records<br>or<br>up to 150 x 120 seconds swing records<br>or<br>combination of transient, swing and optionally event records with a total number of records limited to 150 | Transient record length is user-configurable (range from 0.2 to 2 seconds); transient record pre-trigger time is user-configurable (range from 0.10 to 0.5 seconds).<br>Swing record length is user-configurable (range from 60 to 120 seconds); swing record pre-trigger time is fixed at 30 seconds.<br>Viewing software provides waveform, symmetrical components and harmonic analysis. |
| Transient | 96 s/c oscillography of all analog and external input digital channels | Records up to the 25th harmonic.<br>Viewing software provides waveform, symmetrical components and harmonic analysis. |
| Dynamic Swing | 1 sample/cycle or 60 samples/second | Line positive sequence voltage, current and frequency, W Var and Z for each of the 6 feeder input. Each swing record can be up to maximum 120 seconds. |
| Events | 250 | 1 ms resolution. When “event auto save” is enabled a compressed event record is created approximately every 230 events. |

| Table A.9: B-PRO Model 4000 Specification | | |
|---|---|---|
| A/D Resolution | 16 bits, 65536 counts full scale peak – peak | |
| **Input and Output:** | | |
| Analog Input Channels | 18 currents and 3 voltages | |
| Analog Voltage Inputs<br>1 set of 3-phase voltage inputs<br>(3 voltage channels | Nominal Voltage<br>Continuous rating<br>Maximum over-scale thermal rating<br>Thermal Rating<br>Burden | Vn = 69 Vrms<br>2x Vn = 138 Vrms<br>3x Vn = 207 Vrms for 10 seconds<br>400 Arms for 1 second<br><0.15 VA @ 69 Vrms |
| Analog Current Inputs<br>6 sets of 3-phase current inputs<br>(18 current channels) | Nominal Current<br>Full Scale/Continuous<br>Maximum full-scale rating<br>Burden | In = 5 or 1 Arms<br>3x In = 15 or 3 Arms<br>40x In = 200 Arms or 40 Arms symmetrical<br><0.25 VA @ 5 Arms |
| Burden (digital inputs) | Burden resistance: > 10 k ohms | |
| Isolation | 2 kV optical isolation | |
| External Inputs (digital ) | 9 isolated inputs. | Optional 48/125/250 Vdc nominal, externally wetted. |
| Output Relays (contacts) | 14 programmable outputs and 1 relay inoperative contact (N.C) | Externally wetted<br>Make: 30 A as per IEEE C37.90<br>Carry: 8 A<br>Break: 0.9 A at 125 Vdc resistive<br>0.35 A at 250 Vdc resistive |
| **Interface & Communication:** | | |
| Front Display | 248 x 128 graphics LCD | |
| Front Panel Indicators | 16 LEDs | 11 Targets, Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm |
| Front User Interface | USB port and 100BASE-T Ethernet port | Full Speed USB 2.0, 100BASE-T |
| Rear User Interface | LAN Port 1: 100BASE – copper or optical<br>LAN Port 2: 100BASE – copper or optical<br>Two Serial RS-232 ports to 115 kbd | Copper: RJ45, 100BASE-T<br>Optical: 100BASE-FX, Multimode, 1300 nm, ST style connector<br>Com port can support an external modem |
| Internal Modem | 33.6 Kbps, V.32 bis | Optional internal modem |
| SCADA Interface | DNP3 or Modbus | DNP3: Ethernet or RS-232, Modbus: RS-232 |
| Time Sync | IRIG-B, BNC connector | Modulated or unmodulated, auto-detect |
| Self Checking/Relay Inoperative | 1 contact | Closed when relay inoperative. |
| **Environmental:** | | |
| Ambient Temperature Range | -40C to 85C for 16 hours<br>-40C to 70C continuous | IEC 60068-2-1/IEC 60068-2-2 |
| Humidity | Up to 95% without condensation | IEC 60068-2-30 |
| Insulation Test (Hi-Pot) | Power supply, analog inputs, external inputs, output contacts at 2 kV, 50/60 Hz, 1 minute | IEEE C37.90.1/(IEC 61000-4-4/IEC 60255-22-4): Class 3 |

| Table A.9: B-PRO Model 4000 Specification | | |
|---|---|---|
| Electrical Fast Transient | Tested to level 4 – 4.0 kV 2.5/5 kHz on power and I/O lines | IEEE C37.90.1: 4kV/IEC 60255-22-4 Class 3/IEC 61000-4-4: Level 3 |
| Oscillatory Transient | Test level = 2.5kV | IEEE C37.90.1: 2.5 kV/IEC 60255-22-1: Level 3/IEC 61000-4-12): Level 3 |
| RFI Susceptibility | 10 V/m modulated, 35 V/m unmodulated | IEEE C37.90.2: 35 V/m/(IEC 255-22-3/ IEC 61000-43): Level 3 |
| Vibration, Shock and Bump | 5g and 15g | (IEC 60255-21-1, 2 / IEC 60068 2-8, 27, 29): Class 1 |
| Conducted RF Immunity | | (IEC 60255-22-6 / IEC 61000-4-6): Level 3 |
| Voltage Interruptions | 200 ms interrupt | IEC 60255-11 / IEC 61000-4-11 |
| Sinusoidal Vibration | | IEC/EN 60255-21/1, IEC/EN 60068-2-6, Class 1 |
| **Physical:** | | |
| Weight | 9.55 kg | 21 lbs |
| Dimensions | 3U height 13.2 cm | 3U high, 5.2" |
| | 48.26 cm rack mount | 19" rack mount |
| | 32.8 cm deep | 12.9” deep |
| Mounting | Horizontal | |
| **Time Synchronization and Accuracy:** | | |
| External Time Source | The B-PRO relay is synchronized using IRIG-B input (modulated or unmodulated) auto detect. | Free Running Accuracy: In the absence of an external time source, the relay maintains time with a maximum ±15 minutes drift per year over the full operating temperature range, and maximum ±90 seconds drift per year at a constant temperature of 25°C. The relay can detect loss or re-establishment of external time source and automatically switch between internal and external time. |
| Synchronization Accuracy | Sampling clocks synchronized with the time source (internal or external). | |
| **Overall B-PRO Accuracies:** | | |
| Current | ± 2.5% of inputs from 0.1 to 1.0 x nominal current (In) | |
| | ± 1.0% of inputs from 1.0 to 40.0 x nominal current (In) | |
| Voltage | ± 1.0% of inputs from 0.01 to 2.0 x nominal voltage (Vn) | |
| Timers | ± 3 ms of set value | |
| Inverse Overcurrent Times | ± 2.5% or ± 1 cycle of selected curve | |
| Definite Overcurrent Times | ± 2.5% or ± 1 cycle non-directional | |
| | ± 2.5% or ± 1.5 cycle directional | |
| Frequency Timers | ± 3 ms of set value plus 1.25 cycles to 1.75 cycles of inherent delay | |

| Table A.9: B-PRO Model 4000 Specification | |
|---|---|
| Burden | AC Voltage Inputs, < 0.15 VA @ 69 volts |
| | AC Current Inputs, < 0.50 VA @ 5 amps |

# Appendix B IED Settings and Ranges

When a setting has been completed in the B-PRO Offliner Settings software, it can be printed along with the ranges available for these settings. This is a view only option, that is, if the user wants to change settings they must go back into the settings portion dealing with that setting to make changes. The summary is however, a quick way of having a look at all the settings in a very compact form.

The top part of the settings summary identifies the date that the settings were done, the relay identification, the station that the relay is applied and the location.

The setting summary provides a list of all the current and voltage analog input quantity names used for line protection and used for recording. External Inputs and Output contact names are also identified on this summary.

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| Relay Identification | | | |
| Settings Version | 402 | | |
| Ignore Serial Number | No | | |
| Serial Number | BPRO-4000-090430-01 | | |
| Nominal CT Secondary Current | 5:00 AM | | |
| Nominal System Frequency | 60 Hz | | |
| Unit ID | UnitID | | |
| Comments | Comments | | |
| Date Created-Modified | 6/8/2009 11:05 | | |
| Station Name | Station Name | | |
| Station Number | 1 | | |
| Location | Location | | |
| Equipment Protected | Bus | | |
| Analog Input Names | | | |
| Voltage Input Name | BUS PT 1 | | |
| VA | Voltage A | | |
| VB | Voltage B | | |
| VC | Voltage C | | |
| Input 1 | Input1 | | |
| IA1 | Input1 Current A | | |
| IB1 | Input1 Current B | | |
| IC1 | Input1 Current C | | |
| Input 2 | Input2 | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| IA2 | Input2 Current A | | |
| IB2 | Input2 Current B | | |
| IC2 | Input2 Current C | | |
| Input 3 | Input3 | | |
| IA3 | Input3 Current A | | |
| IB3 | Input3 Current B | | |
| IC3 | Input3 Current C | | |
| Input 4 | Input4 | | |
| IA4 | Input4 Current A | | |
| IB4 | Input4 Current B | | |
| IC4 | Input4 Current C | | |
| Input 5 | Input5 | | |
| IA5 | Input5 Current A | | |
| IB5 | Input5 Current B | | |
| IC5 | Input5 Current C | | |
| Input 6 | Input6 | | |
| IA6 | Input6 Current A | | |
| IB6 | Input6 Current B | | |
| IC6 | Input6 Current C | | |
| External Input Names | | | |
| 1 | EI Spare 1 | | |
| 2 | EI Spare 2 | | |
| 3 | EI Spare 3 | | |
| 4 | EI Spare 4 | | |
| 5 | EI Spare 5 | | |
| 6 | EI Spare 6 | | |
| 7 | EI Spare 7 | | |
| 8 | EI Spare 8 | | |
| 9 | EI Spare 9 | | |
| Output Contact Names | | | |
| Output 1 | Out Spare 1 | | |
| Output 2 | Out Spare 2 | | |
| Output 3 | Out Spare 3 | | |
| Output 4 | Out Spare 4 | | |
| Output 5 | Out Spare 5 | | |
| Output 6 | Out Spare 6 | | |
| Output 7 | Out Spare 7 | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| Output 8 | Out Spare 8 | | |
| Output 9 | Out Spare 9 | | |
| Output 10 | Out Spare 10 | | |
| Output 11 | Out Spare 11 | | |
| Output 12 | Out Spare 12 | | |
| Output 13 | Out Spare 13 | | |
| Output 14 | Out Spare 14 | | |
| System Parameters | | | |
| Bus1 Base MVA | 100 | MVA Primary | 1.0 to 10000.0 |
| Bus2 Base MVA | 100 | MVA Primary | 1.0 to 10000.0 |
| Bus Voltage | 230 | kV Primary | 1.0 to 1000.0 |
| PT Turns Ratio | 2000 | :1 | 1.0 to 10000.0 |
| Phase Rotation | ABC | | |
| Directional Control Alpha | 0 | ...° | -179.9 to 180.0 |
| Directional Control Beta | 180 | ...° | 0.1 to 360.0 |
| Winding/CT Connections | | | |
| Differential Zone | Bus 1 only | | |
| Bus side: | | | |
| Voltage | 230 | kV Primary | 1.0 to 1000.0 |
| Connection | Y | | |
| Phase | 0° degree ref (fixed) | | |
| Non-Bus side: | | | |
| Voltage | 115 | kV Primary | 1.0 to 1000.0 |
| Connection | Y | | |
| Phase | 0° | | |
| Transformer 3 Phase MVA | 60 | MVA Primary | 1.0 to 2000.0 |
| CT Connections | | | |
| Input 1 [Input1] | | | |
| Connect to | Bus 1 | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100 | :1 | 1.0 to 502.0 |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 2 [Input2] | | | |
| Connect to | Bus 1 | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100 | :1 | 1.0 to 502.0 |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 3 [Input3] | | | |
| Connect to | Bus 1 | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100 | :1 | 1.0 to 502.0 |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 4 [Input4] | | | |
| Connect to | Bus 1 | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100 | :1 | 1.0 to 502.0 |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 5 [Input5] | | | |
| Connect to | Bus 1 | | |
| CT Connection | Y (fixed) | | |
| CT Phase | 0° (fixed) | | |
| CT Turns Ratio (to 1) | 100 | :1 | 1.0 to 502.0 |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |
| Exclude When | High | | |
| Input 6 [Input6] | | | |
| Connect to | Bus 1 | | |
| CT Connection | Y | | |
| CT Phase | 0° | | |
| CT Turns Ratio (to 1) | 100 | :1 | 1.0 to 502.0 |
| Digital Control | Enabled | | |
| Digital Control Selection | Not Used | | |

| Table B.10: Settings Summary - B-PRO 4000 | | | |
|---|---|---|---|
| **Name** | **Symbol/Value** | **Unit** | **Range** |
| Exclude When | High | | |
| Protection Summary | | | |
| 87B-1 | Disabled | | |
| 87B-2 | Disabled | | |
| 87T | Disabled | | |
| 59-1 | Disabled | | |
| 59-2 | Disabled | | |
| 27-1 | Disabled | | |
| 27-2 | Disabled | | |
| 60 | Disabled | | |
| 81 O/F-1 | Disabled | | |
| 81 O/F-2 | Disabled | | |
| 81 U/F-1 | Disabled | | |
| 81 U/F-2 | Disabled | | |
| Input 1 [Input1] Protection | | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50BF | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 2 [Input2] Protection | | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50BF | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 3 [Input3] Protection | | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |

| Table B.10: Settings Summary - B-PRO 4000 | | | |
|---|---|---|---|
| **Name** | **Symbol/Value** | **Unit** | **Range** |
| 50BF | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 4 [Input4] Protection | | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50BF | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 5 [Input5] Protection | | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50BF | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |
| Input 6 [Input6] Protection | | | |
| 50LS-1 | Disabled | | |
| 50LS-2 | Disabled | | |
| 50BF | Disabled | | |
| 50 | Disabled | | |
| 51 | Disabled | | |
| 50N | Disabled | | |
| 51N | Disabled | | |
| 46-50 | Disabled | | |
| 46-51 | Disabled | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| 87B-1 - Bus Differential | | | |
| 87B-1 | Disabled | | |
| IOmin | 0.25 | pu | 0.20 to 0.40 |
| Input 1 | 0.63 | A | - |
| Input 2 | 0.63 | A | - |
| Input 3 | 0.63 | A | - |
| Input 4 | 0.63 | A | - |
| Input 5 | 0.63 | A | - |
| Input 6 | 0.63 | A | - |
| IRs | 2 | pu | 1.25 to 50.00 |
| S1 | 20 | % | 12.50 to 40.00 |
| S2 | 40 | % | 30.00 to 200.00 |
| High Curr. Setting | 10 | pu | 0.75 to 100.00 |
| Bus1 Base MVA (set in System Parameters) | 100 | MVA Primary | 1.0 to 10000.0 |
| 87B-2 - Bus Differential | | | |
| 87B-2 | Disabled | | |
| IOmin | 0.25 | pu | 0.20 to 0.40 |
| Input 1 | N/A | | |
| Input 2 | N/A | | |
| Input 3 | N/A | | |
| Input 4 | N/A | | |
| Input 5 | N/A | | |
| Input 6 | N/A | | |
| IRs | 2 | pu | 1.25 to 50.00 |
| S1 | 20 | % | 12.50 to 40.00 |
| S2 | 40 | % | 30.00 to 200.00 |
| High Curr. Setting | 10 | pu | 0.75 to 100.00 |
| Bus2 Base MVA (set in System Parameters) | 100 | MVA Primary | 1.0 to 10000.0 |
| 87T - Transformer Differential | | | |
| 87T | Disabled | | |
| IOmin | 0.25 | pu | 0.20 to 0.40 |
| Input 5 | N/A | | |
| Input 6 | N/A | | |
| IRs | 2 | pu | 1.25 to 50.00 |
| S1 | 20 | % | 12.50 to 40.00 |
| S2 | 40 | % | 30.00 to 200.00 |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| High Curr. Setting | 10 | pu | 0.75 to 100.00 |
| I_2nd / I_fund Ratio | 0.2 | - | 0.05 to 1.00 |
| I 5th Harmonic Restraint | Disabled | | |
| I_5th / I_fund Ratio | 0.2 | - | 0.05 to 1.00 |
| Transformer 3 Phase Capacity | 60 | MVA Primary | 1.0 to 2000.0 |
| 59 - Overvoltage | | | |
| 59-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 70 | V | 60.0 to 138.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| 59-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 70 | V | 60.0 to 138.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| 27 - Undervoltage | | | |
| 27-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 20 | V | 1.0 to 120.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| 27-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 20 | V | 1.0 to 120.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| 60 - Loss of Potential Alarm | | | |
| 60 | Disabled | | |
| 81 - Over-Frequency | | | |
| 81 O/F-1 | Disabled | | |
| Pickup | 61 | Hz | 60.00 to 70.00 |
| Pickup Delay | 2 | s | 0.05 to 99.99 |
| 81 O/F-2 | Disabled | | |
| Pickup | 62 | Hz | 60.00 to 70.00 |
| Pickup Delay | 2 | s | 0.05 to 99.99 |
| 81 - Under-Frequency | | | |
| 81 U/F-1 | Disabled | | |
| Pickup | 59.5 | Hz | 50.00 to 60.00 |
| Pickup Delay | 2 | s | 0.05 to 99.99 |
| 81 U/F-2 | Disabled | | |

| Table B.10: Settings Summary - B-PRO 4000 | | | |
|---|---|---|---|
| **Name** | **Symbol/Value** | **Unit** | **Range** |
| Pickup | 59 | Hz | 50.00 to 60.00 |
| Pickup Delay | 2 | s | 0.05 to 99.99 |
| Input 1 [Input1], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| Input 1 [Input1], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.5 | s | 0.01 to 99.99 |
| Pickup Delay 2 | 1.5 | s | 0.01 to 99.99 |
| Input 1 [Input1], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |

| Table B.10: Settings Summary - B-PRO 4000 | | | |
|---|---|---|---|
| **Name** | **Symbol/Value** | **Unit** | **Range** |
| Input 1 [Input1], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 1 [Input1], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 2 [Input2], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| Input 2 [Input2], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.5 | s | 0.01 to 99.99 |
| Pickup Delay 2 | 1.5 | s | 0.01 to 99.99 |
| Input 2 [Input2], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 2 [Input2], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 2 [Input2], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 3 [Input3], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| Input 3 [Input3], 50BF - Breaker Failure | | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.5 | s | 0.01 to 99.99 |
| Pickup Delay 2 | 1.5 | s | 0.01 to 99.99 |
| Input 3 [Input3], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 3 [Input3], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 3 [Input3], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 4 [Input4], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| Input 4 [Input4], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| Pickup Delay 1 | 0.5 | s | 0.01 to 99.99 |
| Pickup Delay 2 | 1.5 | s | 0.01 to 99.99 |
| Input 4 [Input4], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 4 [Input4], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 4 [Input4], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |

| Table B.10: Settings Summary - B-PRO 4000 | | | |
|---|---|---|---|
| **Name** | **Symbol/Value** | **Unit** | **Range** |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 5 [Input5], 50LS - Low Set Overcurrent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| Input 5 [Input5], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.5 | s | 0.01 to 99.99 |
| Pickup Delay 2 | 1.5 | s | 0.01 to 99.99 |
| Input 5 [Input5], 50/51/67 - Phase Overcurrent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 5 [Input5], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 5 [Input5], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 6 [Input6], 50LS - Low Set Overcur-rent | | | |
| 50LS-1 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| 50LS-2 | Disabled | | |
| Gate Switch | OR | | |
| Pickup | 1 | A | 0.1 to 50.0 |
| Pickup Delay | 0 | s | 0.00 to 99.99 |
| Input 6 [Input6], 50BF - Breaker Failure | | | |
| 50BF | Disabled | | |
| BF Initiated By 87B-1 | Disabled | | |
| BF Initiated By 87B-2 | Disabled | | |
| BF Initiated By 87T | Disabled | | |
| BF Initiated By ProLogic | Disabled | | |
| BF Initiated By Ext. Input | Disabled | | |
| Pickup Delay 1 | 0.5 | s | 0.01 to 99.99 |
| Pickup Delay 2 | 1.5 | s | 0.01 to 99.99 |
| Input 6 [Input6], 50/51/67 - Phase Overcur-rent | | | |
| 50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 6 [Input6], 50N/51N/67 - Neutral Overcurrent | | | |
| 50N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 51N | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Input 6 [Input6], 46-50/46-51/67 - Negative Sequence Overcurrent | | | |
| 46-50 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Pickup Delay | 1 | s | 0.00 to 99.99 |
| Breaker Failure Initiated | Disabled | | |
| 46-51 | Disabled | | |
| Directional Control | forward | | |
| Pickup | 10 | A | 0.5 to 50.0 |
| Breaker Failure Initiated | Disabled | | |
| Curve Type | IEC very inverse | | |
| A | 13.5 | - | - |
| B | 0 | - | - |
| p | 1 | - | - |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| TR | 47.3 | - | 0.10 to 100.0 |
| TMS | 0.5 | - | 0.01 to 10.00 |
| Record Length | | | |
| Fault Record Length | 0.5 | s | 0.2 to 2.0 |
| Prefault Time | 0.2 | s | 0.10 to 0.50 |
| Swing Record Length | 120 | s | 60 to 120 |
| Event Auto Save | Disabled | | |
| PL 1 [ProLogic 1] | | | |
| ProLogic 1 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 2 [ProLogic 2] | | | |
| ProLogic 2 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 3 [ProLogic 3] | | | |
| ProLogic 3 | Disabled | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 4 [ProLogic 4] | | | |
| ProLogic 4 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 5 [ProLogic 5] | | | |
| ProLogic 5 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |

| Table B.10: Settings Summary - B-PRO 4000 | | | |
|---|---|---|---|
| **Name** | **Symbol/Value** | **Unit** | **Range** |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 6 [ProLogic 6] | | | |
| ProLogic 6 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 7 [ProLogic 7] | | | |
| ProLogic 7 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 8 [ProLogic 8] | | | |
| ProLogic 8 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |

| Table B.10: Settings Summary - B-PRO 4000 | | | |
|---|---|---|---|
| **Name** | **Symbol/Value** | **Unit** | **Range** |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 9 [ProLogic 9] | | | |
| ProLogic 9 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 10 [ProLogic 10] | | | |
| ProLogic 10 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 11 [ProLogic 11] | | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| ProLogic 11 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 12 [ProLogic 12] | | | |
| ProLogic 12 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 13 [ProLogic 13] | | | |
| ProLogic 13 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |

| Table B.10: Settings Summary - B-PRO 4000 | | | |
|---|---|---|---|
| **Name** | **Symbol/Value** | **Unit** | **Range** |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 14 [ProLogic 14] | | | |
| ProLogic 14 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| PL 15 [ProLogic 15] | | | |
| ProLogic 15 | Disabled | | |
| Pickup Delay | 0 | s | 0.00 to 999.00 |
| Dropout Delay | 0 | s | 0.00 to 999.00 |
| Operator 1 | | | |
| Input A | <Unused = 0> | | |
| Operator 2 | | | |
| Input B | <Unused = 0> | | |
| Operator 3 | | | |
| Input C | <Unused = 0> | | |
| Operator 4 | | | |
| Input D | <Unused = 0> | | |
| Operator 5 | | | |
| Input E | <Unused = 0> | | |
| Virtual Input Names | | | |
| VI1 | Virtual Input 1 | | |
| VI2 | Virtual Input 2 | | |
| VI3 | Virtual Input 3 | | |
| VI4 | Virtual Input 4 | | |

**Table B.10: Settings Summary - B-PRO 4000**

| Name | Symbol/Value | Unit | Range |
|---|---|---|---|
| VI5 | Virtual Input 5 | | |
| VI6 | Virtual Input 6 | | |
| VI7 | Virtual Input 7 | | |
| VI8 | Virtual Input 8 | | |
| VI9 | Virtual Input 9 | | |
| VI10 | Virtual Input 10 | | |
| VI11 | Virtual Input 11 | | |
| VI12 | Virtual Input 12 | | |
| VI13 | Virtual Input 13 | | |
| VI14 | Virtual Input 14 | | |
| VI15 | Virtual Input 15 | | |
| VI16 | Virtual Input 16 | | |
| VI17 | Virtual Input 17 | | |
| VI18 | Virtual Input 18 | | |
| VI19 | Virtual Input 19 | | |
| VI20 | Virtual Input 20 | | |
| VI21 | Virtual Input 21 | | |
| VI22 | Virtual Input 22 | | |
| VI23 | Virtual Input 23 | | |
| VI24 | Virtual Input 24 | | |
| VI25 | Virtual Input 25 | | |
| VI26 | Virtual Input 26 | | |
| VI27 | Virtual Input 27 | | |
| VI28 | Virtual Input 28 | | |
| VI29 | Virtual Input 29 | | |
| VI30 | Virtual Input 30 | | |
| | | | |

# Appendix C Hardware Description

The relay is a complete line distance protection relay package designed and manufactured with high quality features and recording components. The following information describes the main hardware components of the relay:

## Main Processor Board (MPB)

The MPB has two processor sub-systems which control the operation of the entire relay: the DSP processor and the control processor. The DSP sub-system interfaces to the Relay AC Analog Input Board (RAIB), the Digital Input Board (DIB) and the OCB and manages the protection features of the relay. The control processor manages the user interface and system control features of the relay. Both subsystems operate independently of each other and will continue to function even if the other sub-system fails.

The MPB provides the following functionality:

- DSP processor subsystem which interfaces to the RAIB, the DIB and the OCB and manages the protection features of the relay, with:
  - The floating point DSP to provide fast capture and manipulation of data.
  - RAM and reprogrammable non-volatile Flash memory. Allows operation independent of the control processor and supports field software updates.
- A control processor subsystem which manages the user interface and system control features of the relay, with
  - RAM and reprogrammable non-volatile Flash memory. Allows operation independent of the DSP processor and supports field software upgrades.
  - Settings and recordings stored in non-volatile memory.
  - Runs a Real Time Operating System (RTOS).
  - Provides Ethernet ports and RS-232 ports for modem, SCADA, COM and USB interfaces.
- A time synchronism processor with automatic detection of modulated and un-modulated IRIG-B
- A high speed link is provided between the DSP and control processor subsystems.
- Sophisticated fault detection and “watchdog” recovery hardware
- The MPB also provides the power supply for the entire unit. The power supply operating range is 48-250 Vdc, 100-240 Vac, +/-10%, 50/60 Hz. This wide operating range provides easier installation by eliminating power supply ordering options

## Digital Input Board (DIB)

This board provides 9 digital input channels. Inputs are optically isolated, externally wetted, and factory preset to the customer’s requested voltage level of 48,125 or 250 Vdc. This board interfaces to the MPB.

## Rear Panel Comm Board (RPCB)

The RPCB provides the relay with two RS-232 ports (Ports 122 and 123, DB9F), IRIG-B time synchronization input (Port 121, male BNC), internal modem connection (Port 118, RJ-11) and two Ethernet ports (Ports 119 and 120, RJ-45 or 100BASE-FX MM 1300nm ST, depending upon order specification). The RPCB interfaces to the MPB. Port 119 is the exception in that it interfaces to the GFPCB where it shares an internal switch with the front panel LAN port. The switch then interfaces to the MPB.

## Output Contact Board (BOCB)

The BOCB provides 14 normally open contact outputs for relaying, alarms and control as well as one normally closed output contact for relay inoperative indication. This board interfaces to the MPB.

## Relay AC Analog Sensor Boards (RASB)

Each relay has 3 RASBs each with 6 current transformer inputs. These boards provide 18 current and 6 voltage ac analog measurement inputs. The RASBs interface to the RAIB.

## Relay AC Analog Input Board (RAIB)

The RAIB provides the analog to digital conversion of the 18 ac analog current inputs and the 3 ac analog voltage inputs. The sample rate is fixed at 96 samples/cycle. Each channel is simultaneously sampled using 16-bit analog to digital converters. The digitized data is sent to the MPB for processing and implementation of the protection algorithms.

- A time synchronism processor with automatic detection of modulated and un-modulated IRIG-B
- A high speed link is provided between the DSP and control processor subsystems.
- Sophisticated fault detection and “watchdog” recovery hardware

## Graphics Front Panel Comm Board (GFPCB)

The GFPCB provides the front panel USB and Ethernet ports, the front panel status LEDs and interfaces the MPB to the GFPDB. The MPB controls the state of the LEDs.

## Graphics Front Panel Display Board (GFPDB)

The GFPDB provides the 240 x 128 monochrome graphics front panel display and the keypad. The keypad is used to navigate the menus on the display to control relay operation by a local user.

# Appendix D Event Messages

| Table D.11: B-PRO Event Messages | |
|---|---|
| **Event Message** | **Notes** |
| (Input Name) 50LS-1 ABC | The possible phase information will be A, B, C, AB, BC, CA, ABC |
| (Input Name) 50LS-2 ABC | |
| (Input Name) 50BF-1 ABC Trip | |
| (Input Name) 50BF-2 ABC Trip | |
| (Input Name) 50 on ABC Trip | |
| (Input Name) 51 on ABC Alarm | |
| (Input Name) 51 on ABC Trip | |
| (Input Name) 50N Trip | |
| (Input Name) 51N Alarm | |
| (Input Name) 51N Trip | |
| (Input Name) 46-50 Trip | |
| (Input Name) 46-51 Alarm | |
| (Input Name) 46-51 Trip | |
| 87T Trip on ABC | The possible phase information will be A, B, C, AB, BC, CA, ABC. (IOH) will be added into the message if the setting has been exceeded |
| 87B-1 Trip on ABC | |
| 87B-2 Trip on ABC | |
| 87B-1 Block via CT Sat | |
| 87B-2 Block via CT Sat | |
| 59 O/V-1 on ABC: Trip | The possible phase information will be A, B, C, AB, BC, CA, ABC |
| 59 O/V-2 on ABC: Trip | |
| 27 U/V-1 on ABC: Trip | |
| 27 U/V-2 on ABC: Trip | |
| 60 on phase ABC: Alarm | |
| 81 O/F-1 Trip | |
| 81 O/F-2 Trip | |
| 81 U/F-1 Trip | |
| 81 U/F-2 Trip | |
| (ProLogic Name): PL (1–15) | ProLogic names are user-defined |
| (Ext. Input Name): EI (1–9): status | External input names are user-defined. Status can be "High" or "low" |

| Table D.11: B-PRO Event Messages | |
|---|---|
| (Virtual Inputs Name): VI (1-30): status | Virtual input names are user-defined. Status can be "High" or "low" |
| Self Check: DC Ch.n: Alarm | Continuous dc level on Ch. n, where n=1 to 18. |
| Self Check: DC Alarm Reset | Continuous dc level, condition has reset. |
| Self Check: DC Ch. n: O/P Block | Continuous dc level on Ch. n, where n=1 to 18. Relay is blocked. |
| New Setting Loaded | |
| Manual Settings Load request | Manual or user-initiated settings change |
| Manual Settings Load request completed | Completion of user-initiated settings change. |
| Unit Recalibrated | |
| Unit Restarted | |
| User logged In | |
| | |

Note: For either of the above cases the DSP controller functions continue with normal auxiliary relay outputs provided that DSP failure or Self Check Fail: Block has not occurred.

## Self Check Fail due to DC Offset Detector

The DSP has an algorithm that detects continuous dc levels on the analog inputs and initiates alarms and relay output contact blocking when the measured dc level exceeds the Alarm or Block level. The Alarm level is intended to provide an early indication of a problem. The Block level blocks the relay from false-tripping by preventing any output contact from closing. The Relay Functional LED turns off, but the protection functions will operate normally, with the exception that the output contacts will not be allowed to close. The Relay Inoperative contact will close for a Block condition. The following table describes all the Alarm/Block indication functions.

**Table D.12: Alarm/Block Functions**

| Action | Condition | |
|---|---|---|
| | Alarm | Block |
| Relay Functional LED off | | X |
| Service Required LED on | X | X |
| Self Check Fail Signal high | X | X |
| Relay Inoperative Contact closed | | X |

| Table D.12: Alarm/Block Functions | | |
|---|---|---|
| Output Contacts held open | | X |
| Event Log Message | X | X |
| Status available through SCADA | X | X |

The Self Check Fail signal, which is available in the Output Matrix, TUI metering and SCADA, can be used to signal an alarm. Note that if this signal is mapped to an output contact, the contact which it is mapped to will only be closed for an alarm condition. If the relay is in the Block condition, the Relay Inoperative contact must be used to signal an alarm.

The status of the Self Check Fail is available through the SCADA services provided by the relay. The digital signal Self Check Fail will indicate that DSP has detected a continuous dc level and the analog metering value Self Check Fail Parameter is used to indicate which condition, Alarm or Block. The failure types and which analog values they are associated with are described in the table below. Both signals are available in DNP and Modbus.

| Table D.13: Failure Types | |
|---|---|
| **Point Value** | **Condition** |
| 0 | Normal |
| 1 | Alarm |
| 2 | Block |
| 3 | Alarm has evolved to block |

The Alarm condition is allowed to reset if the continuous dc level drops below the pickup level. The Block condition has no reset level. If power is cycled to the relay it will go into its normal state until the continuous dc level is detected again.

> Note: Self Check Fail appears as “Aux. Failure Alarm” in the settings versions before v2.

# Appendix E Modbus RTU Communication Protocol

All metering values available through the terminal user interface are also available via the Modbus protocol. Additionally, the Modbus protocol supports the reading of unit time and time of the readings and provides access to trip and alarm events, including fault location information. All metering readings can be frozen into a snapshot via the Hold Readings function (see Force Single Coil function, address 0).

The SCADA port supports DNP3 and Modicon Modbus protocols. All metering values available through the terminal user interface are also available via the Modbus protocol. Additionally, the Modbus protocol supports the reading of unit time and time of the readings and provides access to trip and alarm events, including fault location information.

A Hold Readings function is available to freeze all metering readings into a snapshot (see Force Single Coil function, address 0).

**Table E.1: Read Coil Status (Function Code 01)**

| Channel | Address | Value | |
|---|---|---|---|
| Hold Readings | 00001 | 0: Readings not held | 1: Readings held |
| Reserved | 00257 | Reserved | Reserved |
| Output Contact 1 | 00513 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 2 | 00514 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 3 | 00515 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 4 | 00516 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 5 | 00517 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 6 | 00518 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 7 | 00519 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 8 | 00520 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 9 | 00521 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 10 | 00522 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 11 | 00523 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 12 | 00524 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 13 | 00525 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Output Contact 14 | 00526 | 0: Contact Open (inactive) | 1: Contact Closed (active) |
| Input 1 5LS-1 Output | 00769 | 0: Off (inactive) | 1: On (active) |
| Input 1 50LS-2 Output | 00770 | 0: Off (inactive) | 1: On (active) |
| Input 1 50BF-1 Trip | 00771 | 0: Off (inactive) | 1: On (active) |
| Input 1 50BF-2 Trip | 00772 | 0: Off (inactive) | 1: On (active) |
| Input 1 50 Trip | 00773 | 0: Off (inactive) | 1: On (active) |

**Table E.1: Read Coil Status (Function Code 01)**

| | | | |
|---|---|---|---|
| Input 1 51 Alarm | 00774 | 0: Off (inactive) | 1: On (active) |
| Input 1 51 Trip | 00775 | 0: Off (inactive) | 1: On (active) |
| Input 1 50N Trip | 00776 | 0: Off (inactive) | 1: On (active) |
| Input 1 51N Alarm | 00777 | 0: Off (inactive) | 1: On (active) |
| Input 1 51N Trip | 00778 | 0: Off (inactive) | 1: On (active) |
| Input 1 46-50 Trip | 00779 | 0: Off (inactive) | 1: On (active) |
| Input 1 46-51 Alarm | 00780 | 0: Off (inactive) | 1: On (active) |
| Input 1 46-51 Trip | 00781 | 0: Off (inactive) | 1: On (active) |
| Input 2 5LS-1 Output | 00782 | 0: Off (inactive) | 1: On (active) |
| Input 2 50LS-2 Output | 00783 | 0: Off (inactive) | 1: On (active) |
| Input 2 50BF-1 Trip | 00784 | 0: Off (inactive) | 1: On (active) |
| Input 2 50BF-2 Trip | 00785 | 0: Off (inactive) | 1: On (active) |
| Input 2 50 Trip | 00786 | 0: Off (inactive) | 1: On (active) |
| Input 2 51 Alarm | 00787 | 0: Off (inactive) | 1: On (active) |
| Input 2 51 Trip | 00788 | 0: Off (inactive) | 1: On (active) |
| Input 2 50N Trip | 00789 | 0: Off (inactive) | 1: On (active) |
| Input 2 51N Alarm | 00790 | 0: Off (inactive) | 1: On (active) |
| Input 2 51N Trip | 00791 | 0: Off (inactive) | 1: On (active) |
| Input 2 46-50 Trip | 00792 | 0: Off (inactive) | 1: On (active) |
| Input 2 46-51 Alarm | 00793 | 0: Off (inactive) | 1: On (active) |
| Input 2 46-51 Trip | 00794 | 0: Off (inactive) | 1: On (active) |
| Input 3 5LS-1 Output | 00795 | 0: Off (inactive) | 1: On (active) |
| Input 3 50LS-2 Output | 00796 | 0: Off (inactive) | 1: On (active) |
| Input 3 50BF-1 Trip | 00797 | 0: Off (inactive) | 1: On (active) |
| Input 3 50BF-2 Trip | 00798 | 0: Off (inactive) | 1: On (active) |
| Input 3 50 Trip | 00799 | 0: Off (inactive) | 1: On (active) |
| Input 3 51 Alarm | 00800 | 0: Off (inactive) | 1: On (active) |
| Input 3 51 Trip | 00801 | 0: Off (inactive) | 1: On (active) |
| Input 3 50N Trip | 00802 | 0: Off (inactive) | 1: On (active) |
| Input 3 51N Alarm | 00803 | 0: Off (inactive) | 1: On (active) |
| Input 3 51N Trip | 00804 | 0: Off (inactive) | 1: On (active) |
| Input 3 46-50 Trip | 00805 | 0: Off (inactive) | 1: On (active) |
| Input 3 46-51 Alarm | 00806 | 0: Off (inactive) | 1: On (active) |
| Input 3 46-51 Trip | 00807 | 0: Off (inactive) | 1: On (active) |
| Input 4 5LS-1 Output | 00808 | 0: Off (inactive) | 1: On (active) |
| Input 4 50LS-2 Output | 00809 | 0: Off (inactive) | 1: On (active) |
| Input 4 50BF-1 Trip | 00810 | 0: Off (inactive) | 1: On (active) |
| Input 4 50BF-2 Trip | 00811 | 0: Off (inactive) | 1: On (active) |
| Input 4 50 Trip | 00812 | 0: Off (inactive) | 1: On (active) |

| Table E.1: Read Coil Status (Function Code 01) | | | |
|---|---|---|---|
| Input 4 51 Alarm | 00813 | 0: Off (inactive) | 1: On (active) |
| Input 4 51 Trip | 00814 | 0: Off (inactive) | 1: On (active) |
| Input 4 50N Trip | 00815 | 0: Off (inactive) | 1: On (active) |
| Input 4 51N Alarm | 00816 | 0: Off (inactive) | 1: On (active) |
| Input 4 51N Trip | 00817 | 0: Off (inactive) | 1: On (active) |
| Input 4 46-50 Trip | 00818 | 0: Off (inactive) | 1: On (active) |
| Input 4 46-51 Alarm | 00819 | 0: Off (inactive) | 1: On (active) |
| Input 4 46-51 Trip | 00820 | 0: Off (inactive) | 1: On (active) |
| Input 5 5LS-1 Output | 00821 | 0: Off (inactive) | 1: On (active) |
| Input 5 50LS-2 Output | 00822 | 0: Off (inactive) | 1: On (active) |
| Input 5 50BF-1 Trip | 00823 | 0: Off (inactive) | 1: On (active) |
| Input 5 50BF-2 Trip | 00824 | 0: Off (inactive) | 1: On (active) |
| Input 5 50 Trip | 00825 | 0: Off (inactive) | 1: On (active) |
| Input 5 51 Alarm | 00826 | 0: Off (inactive) | 1: On (active) |
| Input 5 51 Trip | 00827 | 0: Off (inactive) | 1: On (active) |
| Input 5 50N Trip | 00828 | 0: Off (inactive) | 1: On (active) |
| Input 5 51N Alarm | 00829 | 0: Off (inactive) | 1: On (active) |
| Input 5 51N Trip | 00830 | 0: Off (inactive) | 1: On (active) |
| Input 5 46-50 Trip | 00831 | 0: Off (inactive) | 1: On (active) |
| Input 5 46-51 Alarm | 00832 | 0: Off (inactive) | 1: On (active) |
| Input 5 46-51 Trip | 00833 | 0: Off (inactive) | 1: On (active) |
| Input 6 5LS-1 Output | 00834 | 0: Off (inactive) | 1: On (active) |
| Input 6 50LS-2 Output | 00835 | 0: Off (inactive) | 1: On (active) |
| Input 6 50BF-1 Trip | 00836 | 0: Off (inactive) | 1: On (active) |
| Input 6 50BF-2 Trip | 00837 | 0: Off (inactive) | 1: On (active) |
| Input 6 50 Trip | 00838 | 0: Off (inactive) | 1: On (active) |
| Input 6 51 Alarm | 00839 | 0: Off (inactive) | 1: On (active) |
| Input 6 51 Trip | 00840 | 0: Off (inactive) | 1: On (active) |
| Input 6 50N Trip | 00841 | 0: Off (inactive) | 1: On (active) |
| Input 6 51N Alarm | 00842 | 0: Off (inactive) | 1: On (active) |
| Input 6 51N Trip | 00843 | 0: Off (inactive) | 1: On (active) |
| Input 6 46-50 Trip | 00844 | 0: Off (inactive) | 1: On (active) |
| Input 6 46-51 Alarm | 00845 | 0: Off (inactive) | 1: On (active) |
| Input 6 46-51 Trip | 00846 | 0: Off (inactive) | 1: On (active) |
| 87T Trip | 00847 | 0: Off (inactive) | 1: On (active) |
| 87B-1 Trip | 00848 | 0: Off (inactive) | 1: On (active) |
| 59-1 Trip | 00849 | 0: Off (inactive) | 1: On (active) |
| 59-2 Trip | 00850 | 0: Off (inactive) | 1: On (active) |
| 27-1 Trip | 00851 | 0: Off (inactive) | 1: On (active) |

**Table E.1: Read Coil Status (Function Code 01)**

| | | | |
|---|---|---|---|
| 27-2 Trip | 00852 | 0: Off (inactive) | 1: On (active) |
| 60 Alarm | 00853 | 0: Off (inactive) | 1: On (active) |
| 81O-1 Trip | 00854 | 0: Off (inactive) | 1: On (active) |
| 81O-2 Trip | 00855 | 0: Off (inactive) | 1: On (active) |
| 81U-1 Trip | 00856 | 0: Off (inactive) | 1: On (active) |
| 81U-2 Trip | 00857 | 0: Off (inactive) | 1: On (active) |
| Self Check Fail | 00858 | 0: Off (inactive) | 1: On (active) |
| ProLogic 1 | 00859 | 0: Off (inactive) | 1: On (active) |
| ProLogic 2 | 00860 | 0: Off (inactive) | 1: On (active) |
| ProLogic 3 | 00861 | 0: Off (inactive) | 1: On (active) |
| ProLogic 4 | 00862 | 0: Off (inactive) | 1: On (active) |
| ProLogic 5 | 00863 | 0: Off (inactive) | 1: On (active) |
| ProLogic 6 | 00864 | 0: Off (inactive) | 1: On (active) |
| ProLogic 7 | 00865 | 0: Off (inactive) | 1: On (active) |
| ProLogic 8 | 00866 | 0: Off (inactive) | 1: On (active) |
| ProLogic 9 | 00867 | 0: Off (inactive) | 1: On (active) |
| ProLogic 10 | 00868 | 0: Off (inactive) | 1: On (active) |
| ProLogic 11 | 00869 | 0: Off (inactive) | 1: On (active) |
| ProLogic 12 | 00870 | 0: Off (inactive) | 1: On (active) |
| ProLogic 13 | 00871 | 0: Off (inactive) | 1: On (active) |
| ProLogic 14 | 00872 | 0: Off (inactive) | 1: On (active) |
| ProLogic 15 | 00873 | 0: Off (inactive) | 1: On (active) |
| 87T Restraint | 00874 | 0: Off (inactive) | 1: On (active) |
| 87T Unrestrained | 00875 | 0: Off (inactive) | 1: On (active) |
| 87B-1 Unrestrained | 00876 | 0: Off (inactive) | 1: On (active) |
| 87B-1 Block via Saturation | 00877 | 0: Off (inactive) | 1: On (active) |
| 87B-2 Trip | 00878 | 0: Off (inactive) | 1: On (active) |
| 87B-2 Unrestrained | 00879 | 0: Off (inactive) | 1: On (active) |
| 87B-2 Block via Saturation | 00880 | 0: Off (inactive | 1: On (active) |

**Table E.2: Read Input Status (Function Code 02)**

| Channel | Address | Value | |
|---|---|---|---|
| External I/P 1 | 10001 | 0: Off (inactive) | 1: On (active) |
| External I/P 2 | 10002 | 0: Off (inactive) | 1: On (active) |
| External I/P 3 | 10003 | 0: Off (inactive) | 1: On (active) |
| External I/P 4 | 10004 | 0: Off (inactive) | 1: On (active) |
| External I/P 5 | 10005 | 0: Off (inactive) | 1: On (active) |

| Table E.2: Read Input Status (Function Code 02) | | | |
|---|---|---|---|
| External I/P 6 | 10006 | 0: Off (inactive) | 1: On (active) |
| External I/P 7 | 10007 | 0: Off (inactive) | 1: On (active) |
| External I/P 8 | 10008 | 0: Off (inactive) | 1: On (active) |
| External I/P 9 | 10009 | 0: Off (inactive) | 1: On (active) |
| External Input 1 Change of state latch | 10257 | 0: Off (inactive) | 1: On (active) |
| External Input 2 Change of state latch | 10258 | 0: Off (inactive) | 1: On (active) |
| External Input 3 Change of state latch | 10259 | 0: Off (inactive) | 1: On (active) |
| External Input 4 Change of state latch | 10260 | 0: Off (inactive) | 1: On (active) |
| External Input 5 Change of state latch | 10261 | 0: Off (inactive) | 1: On (active) |
| External Input 6 Change of state latch | 10262 | 0: Off (inactive) | 1: On (active) |
| External Input 7 Change of state latch | 10263 | 0: Off (inactive) | 1: On (active) |
| External Input 8 Change of state latch | 10264 | 0: Off (inactive) | 1: On (active) |
| External Input 9 Change of state latch | 10265 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #1 | 10513 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #2 | 10514 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #3 | 10515 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #4 | 10516 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #5 | 10517 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #6 | 10518 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #7 | 10519 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #8 | 10520 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #9 | 10521 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #10 | 10522 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #11 | 10523 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #12 | 10524 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #13 | 10525 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #14 | 10526 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #15 | 10527 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #16 | 10528 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #17 | 10529 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #18 | 10530 | 0: Off (inactive) | 1: On (active) |
| Virtual Input #19 | 10531 | 0: Off (inactive) | 1: On (active) |

| Table E.3: Read Holding Registers (Function Code 03 | | | |
|---|---|---|---|
| **Channel** | **Address** | **Units** | **Scale** |
| B-PRO Clock Time (UTC). Read all in same query to ensure consistent time reading data | | | |
| Milliseconds Now | 40001 | 0-999 | 1 |
| Seconds Now | 40002 | 0-59 | 1 |
| Minutes Now | 40003 | 0-59 | 1 |
| Hours Now | 40004 | 0-23 | 1 |
| Day of Year Now | 40005 | 1-365 (up to 366 if leap year) | 1 |
| Years since 1900 | 40006 | 90-137 | 1 |
| Sync'd to IRIG-B | 40007 | 0: No 1: Yes | 1 |
| Time of Acquisition (UTC). Read all in same query to ensure consistent time reading data | | | |
| Milliseconds Now | 40008 | 0-999 | 1 |
| Seconds Now | 40009 | 0-59 | 1 |
| Minutes Now | 40010 | 0-59 | 1 |
| Hours Now | 40011 | 0-23 | 1 |
| Day of Year Now | 40012 | 1-365 (up to 366 if leap year) | 1 |
| Years since 1900 | 40013 | 90-137 | 1 |
| Sync'd to IRIG-B | 40014 | 0: No 1: Yes | 1 |
| Offset of UTC to IED local time. | 40015 | 2's complement half hours, North America is negative | 1 |
| VA Magnitude | 40257 | KV | 10 |
| VA Angle | 40258 | Degrees | 10 |
| VB Magnitude | 40259 | KV | 10 |
| VB Angle | 40260 | Degrees | 10 |
| VC Magnitude | 40261 | KV | 10 |
| VC Angle | 40262 | Degrees | 10 |
| I1A Magnitude | 40263 | A | 1 |
| I1A Angle | 40264 | Degrees | 10 |
| I1B Magnitude | 40265 | A | 1 |
| I1B Angle | 40266 | Degrees | 10 |
| I1C Magnitude | 40267 | A | 1 |
| I1C Angle | 40268 | Degrees | 10 |
| I2A Magnitude | 40269 | A | 1 |
| I2A Angle | 40270 | Degrees | 10 |
| I2B Magnitude | 40271 | A | 1 |
| I2B Angle | 40272 | Degrees | 10 |
| I2C Magnitude | 40273 | A | 1 |
| I2C Angle | 40274 | Degrees | 10 |

**Table E.3: Read Holding Registers (Function Code 03**

| | | | |
|---|---|---|---|
| I3A Magnitude | 40275 | A | 1 |
| I3A Angle | 40276 | Degrees | 10 |
| I3B Magnitude | 40277 | A | 1 |
| I3B Angle | 40278 | Degrees | 10 |
| I3C Magnitude | 40279 | A | 1 |
| I3C Angle | 40280 | Degrees | 10 |
| I4A Magnitude | 40281 | A | 1 |
| I4A Angle | 40282 | Degrees | 10 |
| I4B Magnitude | 40283 | A | 1 |
| I4B Angle | 40284 | Degrees | 10 |
| I4C Magnitude | 40285 | A | 1 |
| I4C Angle | 40286 | Degrees | 10 |
| I5A Magnitude | 40287 | A | 1 |
| I5A Angle | 40288 | Degrees | 10 |
| I5B Magnitude | 40289 | A | 1 |
| I5B Angle | 40290 | Degrees | 10 |
| I5C Magnitude | 40291 | A | 1 |
| I5C Angle | 40292 | Degrees | 10 |
| I6A Magnitude | 40293 | A | 1 |
| I6A Angle | 40294 | Degrees | 10 |
| I6B Magnitude | 40295 | A | 1 |
| I6B Angle | 40296 | Degrees | 10 |
| I6C Magnitude | 40297 | A | 1 |
| I6C Angle | 40298 | Degrees | 10 |
| Transformer IA Operating | 40299 | A | 1 |
| Transformer IB Operating | 40300 | A | 1 |
| Transformer IC Operating | 40301 | A | 1 |
| Transformer IA Restraint | 40302 | A | 1 |
| Transformer IB Restraint | 40303 | A | 1 |
| Transformer IC Restraint | 40304 | A | 1 |
| Bus IA Operating | 40305 | A | 1 |
| Bus IB Operating | 40306 | A | 1 |
| Bus IC Operating | 40307 | A | 1 |
| Bus IA Restraint | 40308 | A | 1 |
| Bus IB Restraint | 40309 | A | 1 |
| Bus IC Restraint | 40310 | A | 1 |
| Input 1 P | 40311 | MW | 10 |
| Input 1 Q | 40312 | MVARS | 10 |
| Input 2 P | 40313 | MW | 10 |

**Table E.3: Read Holding Registers (Function Code 03**

| | | | |
|---|---|---|---|
| Input 2 Q | 40314 | MVARS | 10 |
| Input 3 P | 40315 | MW | 10 |
| Input 3 Q | 40316 | MVARS | 10 |
| Input 4 P | 40317 | MW | 10 |
| Input 4 Q | 40318 | MVARS | 10 |
| Input 5 P | 40319 | MW | 10 |
| Input 5 Q | 40320 | MVARS | 10 |
| Input 6 P | 40321 | MW | 10 |
| Input 6 Q | 40322 | MVARS | 10 |
| Positive Sequence V | 40323 | kV | 10 |
| Frequency | 40324 | Hz | 100 |
| 87B-2 IA Operating | 40325 | A | 1 |
| 87B-2 IB Operating | 40326 | A | 1 |
| 87B-2 IC Operating | 40327 | A | 1 |
| 87B-2 IA Restraint | 40328 | A | 1 |
| 87B-2 IB Restraint | 40329 | A | 1 |
| 87B-2 IC Restraint | 40330 | A | 1 |
| Self Check Fail Parameter | 40331 | N/A | 1 |

**Table E.4: Read Input Register (Function Code 04)**

No input registers supported. Response from IED indicates “ILLEGAL FUNCTION.”

**Table E.5: Force Single Coil (Function Code 05)**

Only the "hold readings" coil can be forced. When active, this coil locks all coil, input and holding register readings simultaneously at their present values. When inactive, coil, input and holding register values will read their most recently available state.

| Channel | Type | Address | Value |
|---|---|---|---|
| Hold Readings | Read/Write | 01 | 0000: Readings update normally (inactive)<br>FF00: Hold readings (active) |

**Table E.6: Preset Single Register (Function Code 06)**

| Channel | Address | Value | Scaled Up By |
|---|---|---|---|
| Event Message Control (See below for details of use) | | | |
| Refresh event list | 40513 | No data required | N/A |

| Table E.6: Preset Single Register (Function Code 06) | | | |
|---|---|---|---|
| Acknowledge the current event and get the next event | 40514 | No data required | N/A |
| Get the next event (without acknowl-edge) | 40515 | No data required | N/A |

| Table E.7: Diagnostic Subfunctions (Function Code 08) | |
|---|---|
| Return Query Data (Subfunction 00) | This provides an echo of the submitted message. |
| Restart Comm. Option (Subfunction 01) | This restarts the Modbus communications process. |
| Force Listen Only Mode (Subfunction 04) | No response is returned. IED enters "Listen Only" mode. This mode can only be exited by the "Restart Comm. Option" command. |

| Table E.8: Report Slave ID (Function Code 17/0x11) | | | |
|---|---|---|---|
| A fixed response is returned by the IED, including system model, version and issue numbers. | | | |
| **Channel** | **Type** | **Bytes** | **Value** |
| Model Number | Read Only | 0 and 1 | 21FC = 8700 decimal |
| Version Number | Read Only | 2 and 3 | Version number |
| Issue Number | Read Only | 4 and 5 | Issue number |

- The B-PRO IED model number is 4000.
- Version and issue will each be positive integers, say X and Y.
- The B-PRO is defined as “Model 4000, Version X Issue Y”

| Table E.9: Accessing B-PRO Event Information | |
|---|---|
| All B-PRO detector event messages displayed in the Event Log are available via Modbus. This includes fault location information. The following controls are available. | |
| Refresh Event List | (Function Code 6, address 40513): Fetches the latest events from the B-PRO's event log and makes them available for Modbus access. The most recent event becomes the current event available for reading. |
| Acknowledge Current Event and Get Next Event | (Function Code 6, address 40514): Clears the current event from the read registers and places the next event into them. An acknowledged event is no longer available for reading. |
| Get Next Event | (Function Code 6, address 40515): Places the next event in the read registers without acknowledging the current event. The current event will reappear in the list when Refresh Event List is used. |
| Size of Current Event Message | (Function Code 3, address 40516): Indicates the number of 16 bit registers used to contain the current event. Event data is stored with two characters per register. A reading of zero indicates that there are no unacknowledged events available in the current set. (NB. The Refresh Event List function can be used to check for new events that have occurred since the last Refresh Event List.) |
| Read Event Message | (Function Code 3, addresses 40517 - 40576): Contains the current event message. Two ASCII characters are packed into each 16 bit register. All unused registers in the set are set to 0. |

**Table E.10: Modbus Event Message Example**

“2002May15 16:45:07.848: 27-1 (U/V) on ABC: Trip”

| Register | Value | | Meaning |
|---|---|---|---|
| | **High Byte** | **Low Byte** | |
| 40516 | 0x00 | 0x19 | Event text size = 25 (0x19 hex) |
| 40517 | 0x20 | 0x20 | ’<sp>’, ’<sp>’ |
| 40518 | 0x32 | 0x30 | ’2’, ’0’ |
| 40519 | 0x30 | 0x32 | ’0’, ’2’ |
| 40520 | 0x40 | 0x61 | ’M’, ’a’ |
| 40521 | 0x79 | 0x31 | ’y’, ’1’ |
| 40522 | 0x35 | 0x20 | ’5’, ’<sp>’ |
| 40523 | 0x31 | 0x36 | ’1’, ’6’ |
| 40524 | 0x3A | 0x34 | ’:’, ’4’ |
| 40525 | 0x35 | 0x3A | ’5’, ’:’ |
| 40526 | 0x30 | 0x37 | ’0’, ’7’ |
| 40527 | 0x2E | 0x38 | ’.’, ’8’ |
| 40528 | 0x34 | 0x38 | ’4’, ’8’ |
| 40529 | 0x20 | 0x3A | ’<sp>’, ’:’ |
| 40530 | 0x20 | 0x32 | ’<sp>’, ’2’ |
| 40531 | 0x37 | 0x2D | ’7’, ’-’ |
| 40532 | 0x31 | 0x20 | ’1’, ’<sp>’ |
| 40533 | 0x28 | 0x55 | ’(’, ’U’ |
| 40534 | 0x2F | 0x56 | ’/’, ’V’ |
| 40535 | 0x29 | 0x20 | ’)’, ’<sp>’ |
| 40536 | 0x6F | 0x6E | ’o’, ’n’ |
| 40537 | 0x20 | 0x41 | ’<sp>’, ’A’ |
| 40538 | 0x42 | 0x43 | ’B’, ’C’ |
| 40539 | 0x3A | 0x20 | ’:’, ’<sp>’ |
| 40540 | 0x54 | 0x72 | ’T’, ’r’ |
| 40541 | 0x69 | 0x70 | ’i’, ’p’ |

# Appendix F DNP3 Device Profile

## Device Properties

This document shows the device capabilities and the current value of each parameter for the default unit configuration as defined in the default configuration file.

| 1.1 Device Identification | Capabilities | Current Value | If configurable, list methods |
|---|---|---|---|
| 1.1.1 Device Function: | ○ Master<br>● Outstation | ○ Master<br>● Outstation | |
| 1.1.2 Vendor Name: | | ERLPhase Power Technologies | |
| 1.1.3 Device Name: | | B-PRO 4000 | |
| 1.1.4 Device manufacturer's hardware version string: | | NA | |
| 1.1.5 Device manufacturer's software version string: | | NA | |
| 1.1.6 Device Profile Document Version Number: | | V01.0, Jan 06, 2011 | |
| 1.1.7 DNP Levels Supported for: | Outstations Only<br>Requests and Responses<br>☐ None<br>☐ Level 1<br>☒ Level 2<br>☐ Level 3 | | |
| 1.1.8 Supported Function Blocks: | ☐ Self-Address Reservation<br>☐ Object 0 - attribute objects<br>☐ Data Sets<br>☐ File Transfer<br>☐ Virtual Terminal<br>☐ Mapping to IEC 61850 Object Models defined in a DNP3 XML file | | |
| 1.1.9 Notable Additions: | • Start-stop (qualifier codes 0x00 and 0x01), limited quantity (qualifier codes 0x07 and 0x08) and indices (qualifier codes 0x17 and 0x28) for Binary Inputs, Binary Outputs and Analog Inputs (object groups 1, 10 and 30)<br>• 32-bit and 16-bit Analog Inputs with and without flag (variations 1, 2, 3 and 4)<br>• Analog Input events with time (variations 3 and 4)<br>• Fault Location information as analog readings<br>• Event Log messages as Object groups 110 and 111 | | |

| 1.1 Device Identification | Capabilities | Current Value | If configurable, list methods |
|---|---|---|---|
| 1.1.10 Methods to set Configurable Parameters: | ☐ XML - Loaded via DNP3 File Transfer<br>☐ XML - Loaded via other transport mechanism<br>☐ Terminal - ASCII Terminal Command Line<br>☒ Software - Vendor software named L-PRO Offliner<br>☐ Proprietary file loaded via DNP3 file transfer<br>☐ Proprietary file loaded via other transport mechanism<br>☐ Direct - Keypad on device front panel<br>☐ Factory - Specified when device is ordered<br>☐ Protocol - Set via DNP3 (e.g. assign class)<br>☐ Other - explain _________________ | | |
| 1.1.11 DNP3 XML files available On-Line: | RdWrFilenameDescription of Contents<br><br>☐ dnpDP.xml Complete Device Profile<br>☐ dnpDPcap.xml Device Profile Capabilities<br>☐ dnpDPcfg.xml Device Profile config. values<br>☐ ☐ _____*.xml ___________________<br><br>*The Complete Device Profile Document contains the capabilities, Current Value, and configurable methods columns.<br>*The Device Profile Capabilities contains only the capabilities and configurable methods columns.<br>*The Device Profile Config. Values contains only the Current Value column. | Not supported | |
| 1.1.12 External DNP3 XML files available Off-line: | Rd WrFilenameDescription of Contents<br>☐ ☐ dnpDP.xml Complete Device Profile<br>☐ ☐ dnpDPcap.xml Device Profile Capabilities<br>☐ ☐ dnpDPcfg.xml Device Profile config. values<br>☐ ☐ _______*.xml ___________________<br><br>*The Complete Device Profile Document contains the capabilities, Current Value, and configurable methods columns.<br>*The Device Profile Capabilities contains only the capabilities and configurable methods columns.<br>*The Device Profile Config. Values contains only the Current Value column. | Not supported | |
| 1.1.13 Connections Supported: | ☒ Serial (complete section 1.2)<br>☒ IP Networking (complete section 1.3)<br>☐ Other, explain ______________________ | | |

| 1.2 Serial Connections | Capabilities | Current Value | If configurable, list methods |
|---|---|---|---|
| 1.2.1 Port Name | Port 122 | | |
| 1.2.2 Serial Connection Parameters: | ☐ Asynchronous - 8 Data Bits, 1 Start Bit, 1 Stop Bit, No Parity<br>☒ Other, explain - Asynchronous with selectable parity | Not configured for DNP | B-PRO Offliner |
| 1.2.3 Baud Rate: | ☐ Fixed at _______<br>☐ Configurable, range _______ to _______<br>☒ Configurable, selectable from 300, 1200, 2400, 9600, 19200, 38400 and 57600<br>☐ Configurable, other, describe_______________ | Not configured for DNP | B-PRO Offliner |
| 1.2.4 Hardware Flow Control (Handshaking):<br>Describe hardware signaling requirements of the interface.<br>Where a transmitter or receiver is inhibited until a given control signal is asserted, it is considered to require that signal prior to sending or receiving characters.<br>Where a signal is asserted prior to transmitting, that signal will be maintained active until after the end of transmission.<br>Where a signal is asserted to enable reception, any data sent to the device when the signal is not active could be discarded. | ☐ None<br>**RS-232 / V.24 / V.28 Options:**<br>Before Tx, Asserts: ☐ RTS ☐ DTR<br>Before Rx, Asserts: ☐ RTS ☐ DTR<br>Always Asserts: ☒ RTS ☒ DTR<br>Before Tx, Requires: Asserted / Deasserted<br>☐ / ☐ CTS<br>☐ / ☐ DCD<br>☐ / ☐ DSR<br>☐ / ☐ RI<br>☐ Rx Inactive<br>Before Rx, Requires: Asserted / Deasserted<br>☐ / ☐ CTS<br>☐ / ☐ DCD<br>☐ / ☐ DSR<br>☐ / ☐ RI<br>Always Ignores:<br>☒ CTS<br>☒ DCD<br>☒ DSR<br>☒ RI<br>Other, explain ____________<br>**RS-422 / V.11 Options:**<br>☐Requires Indication before Rx<br>☐Asserts Control before Tx<br>☐Other, explain ____________<br>**RS-485 Options:**<br>☐Requires Rx inactive before Tx<br>☐Other, explain ____________ | | |
| 1.2.5 Interval to Request Link Status: | ☒ Not Supported<br>☐ Fixed at_________ seconds<br>☐ Configurable, range _____ to ______ seconds<br>☐ Configurable, selectable from __,__,__ seconds<br>☐ Configurable, other, describe______________ | | |
| 1.2.6 Supports DNP3 Collision Avoidance: | ☒ No<br>☐ Yes, explain ______________________ | | |

| 1.2 Serial Connections | Capabilities | Current Value | If configurable, list methods |
|---|---|---|---|
| 1.2.7 Receiver Inter-character Timeout: | ☒ Not checked<br>☐ No gap permitted<br>☐ Fixed at _____ bit times<br>☐ Fixed at _____ ms<br>☐ Configurable, range ____ to ____ bit times<br>☐ Configurable, range ____ to ____ ms<br>☐ Configurable, Selectable from __,__,__bit times<br>☐ Configurable, Selectable from ___, ___, ___ ms<br>☐ Configurable, other, describe______________<br>☐ Variable, explain ____ | | |
| 1.2.8 Inter-character gaps in transmission: | ☒ None (always transmits with no inter-character gap)<br>☐ Maximum _____ bit times<br>☐ Maximum _____ ms | | |

| 1.3 IP Networking | | Capabilities | Current Value | If configurable, list methods |
|---|---|---|---|---|
| 1.3.1 | Port Name | Port 119 and Port 120 | | |
| 1.3.2 | Type of End Point: | ☐ TCP Initiating (Master Only)<br>☒ TCP Listening (Outstation Only)<br>☐ TCP Dual (required for Masters)<br>☒ UDP Datagram (required) | Not configured for DNP | B-PRO Offliner |
| 1.3.3 | IP Address of this Device: | | 192.168.100.101 | B-PRO Mainte-nance utilities |
| 1.3.4 | Subnet Mask: | | Not set | B-PRO Mainte-nance utilities |
| 1.3.5 | Gateway IP Address: | | Not set | B-PRO Mainte-nance utilities |
| 1.3.6 | Accepts TCP Connections or UDP Datagrams from: | ☒ Allows all (show as *.*.*.* in 1.3.7)<br>☒ Limits based on an IP address<br>☒ Limits based on list of IP addresses<br>☐ Limits based on a wildcard IP address<br>☐ Limits based on list of wildcard IP addresses<br>☐ Other validation, explain_________________ | Limits based on an IP address | B-PRO Offliner |
| 1.3.7 | IP Address(es) from which TCP Connections or UDP Datagrams are accepted: | | 192.168.1.1 | B-PRO Offliner |
| 1.3.8 | TCP Listen Port Number: | ☐ Not Applicable (Master w/o dual end point)<br>☐ Fixed at 20,000<br>☒ Configurable, range 1025 to 32737<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | 20,000 | B-PRO Offliner |
| 1.3.9 | TCP Listen Port Number of remote device: | ☒ Not Applicable (Outstation w/o dual end point)<br>☐ Fixed at 20,000<br>☐ Configurable, range _______ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | NA | |
| 1.3.10 | TCP Keep-alive timer: | ☐ Fixed at ___________ms<br>☒ Configurable, range 5 to 3,600 s<br>☐ Configurable, selectable from ___,___,___ms<br>☐ Configurable, other, describe______________ | Disabled | B-PRO Offliner |
| 1.3.11 | Local UDP port: | ☐ Fixed at 20,000<br>☒ Configurable, range 1025 to 32737<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________<br>☐ Let system choose (Master only) | 20,000 | B-PRO Offliner |
| 1.3.12 | Destination UDP port for initial unsolicited null responses (UDP only Outstations): | ☒ None<br>☐ Fixed at 20,000<br>☐ Configurable, range _______ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe_______________ | N/A | |

| 1.3 IP Networking | Capabilities | Current Value | If configurable, list methods |
|---|---|---|---|
| 1.3.13 Destination UDP port for responses: | ☐ None<br>☐ Fixed at 20,000<br>☒ Configurable, range 1025 to 32737<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe_______________<br>☐ Use source port number | 20,000 | B-PRO Offliner |
| 1.3.14 Multiple master connections (Outstations Only): | ☒ Supports multiple masters (Outstations only)<br>If supported, the following methods may be used:<br>☒ Method 1 (based on IP address) - required<br>☒ Method 2 (based on IP port number) - recommended<br>☒ Method 3 (browsing for static data) - optional | Method 1 (based on IP address) | B-PRO Offliner |
| 1.3.15 Time synchronization support: | ☐ DNP3 LAN procedure (function code 24)<br>☐ DNP3 Write Time (not recommended over LAN)<br>☐ Other, explain ________________________<br>☒ Not Supported | | |

| **1.4 Link Layer** | | **Current Value** | **If configurable, list methods** |
|---|---|---|---|
| 1.4.1 Data Link Address: | ☐ Fixed at______<br>☒ Configurable, range 1 to 65519<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | 1 | B-PRO Offliner |
| 1.4.2 DNP3 Source Address Validation: | ☒ Never<br>☐ Always, one address allowed (shown in 1.4.3)<br>☐ Always, any one of multiple addresses allowed<br>☐ (each selectable as shown in 1.4.3)<br>☐ Sometimes, explain________________ | | |
| 1.4.3 DNP3 Source Address(es) expected when Validation is Enabled: | ☐ Configurable to any 16 bit DNP Data Link Address value<br>☐ Configurable, range _______ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | NA | |
| 1.4.4 Self Address Support using address 0xFFFC: | ☐ Yes (only allowed if configurable)<br>☒ No | NA | |
| 1.4.5 Sends Confirmed User Data Frames: | ☐ Always<br>☐ Sometimes, explain _____________________<br>☐ Never<br>☒ Configurable, either always or never | | B-PRO Offliner (to disable, set Data Link Time-out to 0) |
| 1.4.6 Data Link Layer Confirmation Timeout: | ☐ None<br>☐ Fixed at __ ms<br>☒ Configurable, range 0 to 2,000 ms<br>☐ Configurable, selectable from____________ms<br>☐ Configurable, other, describe______________<br>☐ Variable, explain _______________________ | 500 | |
| 1.4.7 Maximum Data Link Retries: | ☐ Never Retries<br>☒ Fixed at 3<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | 3 | |
| 1.4.8 Maximum number of octets Transmitted in a Data Link Frame: | ☒ Fixed at 292<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | 292 | |
| 1.4.9 Maximum number of octets that can be Received in a Data Link Frame: | ☒ Fixed at 292<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | 292 | |

| **1.5 Application Layer** | | **Current Value** | **If configurable, list methods** |
|---|---|---|---|
| 1.5.1 Maximum number of octets Transmitted in an Application Layer Fragment other than File Transfer: | ☒ Fixed at 2048<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | 2048 | |
| 1.5.2 Maximum number of octets Transmitted in an Application Layer Fragment containing File Transfer: | ☐ Fixed at ___________<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | NA | |
| 1.5.3 Maximum number of octets that can be Received in an Application Layer Fragment: | ☒ Fixed at 2048<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________ | 2048 | |
| 1.5.4 Timeout waiting for Complete Application Layer Fragment: | ☐ None<br>☒ Fixed at 2,000 ms<br>☐ Configurable, range _______ to _______ms<br>☐ Configurable, selectable from ___,___,___ms<br>☐ Configurable, other, describe______________<br>☐ Variable, explain _______________________ | 2,000 ms | |
| 1.5.5 Maximum number of objects allowed in a single control request for CROB (group 12): | ☒ Fixed at 16<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________<br>☐ Variable, explain _______________________ | 16 | |
| 1.5.6 Maximum number of objects allowed in a single control request for Analog Outputs (group 41): | ☐ Fixed at _<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________<br>☐ Variable, explain _______________________ | Analog Outputs not supported | |
| 1.5.7 Maximum number of objects allowed in a single control request for Data Sets (groups 85,86,87): | ☐ Fixed at __<br>☐ Configurable, range ________ to _______<br>☐ Configurable, selectable from ____,____,____<br>☐ Configurable, other, describe______________<br>☐ Variable, explain _______________________ | Data Sets not supported | |
| 1.5.8 Supports mixing object groups (AOBs, CROBs and Data Sets) in the same control request: | ☐ Not applicable - controls are not supported<br>☐ Yes<br>☒ No | Analog Outputs not supported | |

| **1.6 Fill Out The Following Items For Outstations Only** | | **Current Value** | **If configurable, list methods** |
|---|---|---|---|
| 1.6.1 Timeout waiting for Application Confirm of solicited response message: | ☐ None<br>☒ Fixed at 5,000 ms<br>☐ Configurable, range _______ to _______ms<br>☐ Configurable, selectable from ___,___,___ms<br>☐ Configurable, other, describe______________<br>☐ Variable, explain _______________________ | 5,000 ms | |
| 1.6.2 How often is time synchronization required from the master? | ☒ Never needs time<br>☐ Within ______ seconds after IIN1.4 is set<br>☐ Periodically every _______ seconds | | |
| 1.6.3 Device Trouble Bit IIN1.6: | ☐ Never used<br>☒ Reason for setting: Unable to access requested data or execute CROB, assuming a valid request has been received | | |
| 1.6.4 File Handle Timeout: | ☒ Not applicable, files not supported<br>☐ Fixed at______ ms<br>☐ Configurable, range _______ to _______ms<br>☐ Configurable, selectable from ___,___,___ms<br>☐ Configurable, other, describe______________<br>☐ Variable, explain _______________________ | | |
| 1.6.5 Event Buffer Overflow Behaviour: | ☐ Discard the oldest event<br>☒ Discard the newest event<br>☐ Other, explain _________________________ | | |
| 1.6.6 Event Buffer Organization: | • Single buffer for the Object Groups 2 and 32, size 200.<br>• Separate buffer for the Object Group 111, size 100.<br>• Separate buffer for the Fault Locator events, size 100. | | |
| 1.6.7 Sends Multi-Fragment Responses: | ☒ Yes<br>☐ No | | |
| 1.6.8 DNP Command Settings preserved through a device reset: | ☐ Assign Class<br>☐ Analog Deadbands<br>☐ Data Set Prototypes<br>☐ Data Set Descriptors | Not supported | |

| **1.7 Outstation Unsolicited Response Support** | | **Current Value** | **If configurable, list methods** |
|---|---|---|---|
| 1.7.1 Supports Unsolicited Reporting: | ☒ Not Supported<br>☐ Configurable, selectable from On and Off | NA | |

| 1.8 Outstation Performance | | Current Value | If configurable, list methods |
|---|---|---|---|
| 1.8.1 Maximum Time Base Drift (milliseconds per minute): | | NA, not synchronized by DNP | |
| 1.8.2 When does outstation set IIN1.4? | ☒ Never<br>☐ Asserted at startup until first Time Synchronization request received<br>☐ Periodically, range ____to____ seconds<br>☐ Periodically, selectable from ____,____,___ seconds<br>☐ Range ____to____ seconds after last time sync<br>☐ Selectable from___,___,___seconds after last time sync<br>☐ When time error may have drifted by range ____to____ ms<br>☐ When time error may have drifted by selectable from ____,____,___ | NA | |
| 1.8.3 Maximum Internal Time Reference Error when set via DNP (ms): | | NA | |
| 1.8.4 Maximum Delay Measurement error (ms): | | NA | |
| 1.8.5 Maximum Response time (ms): | | 100 ms (for the case all supported points mapped to the DNP point lists) | B-PRO Offliner |
| 1.8.6 Maximum time from start-up to IIN 1.4 assertion (ms): | | NA | |
| 1.8.7 Maximum Event Time-tag error for local Binary and Double-bit I/O (ms): | | • 0.1736 ms for 60Hz systems<br>• 0.2083 ms for 50 Hz systems | |
| 1.8.8 Maximum Event Time-tag error for local I/O other than Binary and Double-bit data types (ms): | | • 0.1736 ms for 60Hz systems<br>• 0.2083 ms for 50 Hz systems | |

## Capabilities and Current Settings for Device Database

The following tables identify the capabilities and current settings for each DNP3 data type. Each data type also provides a table defining the data points available in the device, default point lists configuration and a description of how this information can be obtained in case of customized point configuration.

| 2.1 Single-Bit Binary Inputs | | Capabilities | Current Value | If configurable, list methods |
|---|---|---|---|---|
| 2.1.1 | Static Variation reported when variation 0 requested: | ☒ Variation 1 - Single-bit Packed format<br>☐ Variation 2 - Single-bit with flag<br>☐ Based on point Index (add column to table below) | | |
| 2.1.2 | Event Variation reported when variation 0 requested: | ☐ Variation 1 - without time<br>☒ Variation 2 - with absolute time<br>☐ Variation 3 - with relative time<br>☐ Based on point Index (add column to table below) | | |
| 2.1.3 | Event reporting mode: | ☐ Only most recent<br>☒ All events | | |
| 2.1.4 | Binary Inputs included in Class 0 response: | ☒ Always<br>☐ Never<br>☐ Only if point is assigned to Class 1, 2, or 3<br>☐ Based on point Index (add column to table below) | | B-PRO Offliner |
| 2.1.5 | Definition of Binary Input Point List: | ☐ Fixed, list shown in table below<br>☒ Configurable<br>☐ Other, explain_____________________ | Complete list is shown in the table below; points excluded from the default configuration are marked with '*' | B-PRO Offliner |

| | |
|---|---|
| **NOTES** | 1. Binary Inputs are scanned with 1 ms resolution.<br><br>2. Binary Input data points are user selectable; the data points available in the device for any given Binary Input point selection can be obtained through the B-PRO Offliner software (see SCADA Setting Summary). |

| Point Index | Name | Default Class Assigned to Events (1, 2, 3 or none) | Name for State when value is 0 | Name for State when value is 1 | Description |
|---|---|---|---|---|---|
| 0 | External Input 1 | 1 | Inactive | Active | |
| 1 | External Input 2 | 1 | Inactive | Active | |
| 2 | External Input 3 | 1 | Inactive | Active | |
| 3 | External Input 4 | 1 | Inactive | Active | |
| 4 | External Input 5 | 1 | Inactive | Active | |
| 5 | External Input 6 | 1 | Inactive | Active | |
| 6 | External Input 7 | 1 | Inactive | Active | |
| 7 | External Input 8 | 1 | Inactive | Active | |
| 8 | External Input 9 | 1 | Inactive | Active | |
| 9 | Virtual Input 1 | 1 | Inactive | Active | |
| 10 | Virtual Input 2 | 1 | Inactive | Active | |
| 11 | Virtual Input 3 | 1 | Inactive | Active | |
| 12 | Virtual Input 4 | 1 | Inactive | Active | |
| 13 | Virtual Input 5 | 1 | Inactive | Active | |
| 14 | Virtual Input 6 | 1 | Inactive | Active | |
| 15 | Virtual Input 7 | 1 | Inactive | Active | |
| 16 | Virtual Input 8 | 1 | Inactive | Active | |
| 17 | Virtual Input 9 | 1 | Inactive | Active | |
| 18 | Virtual Input 10 | 1 | Inactive | Active | |
| 19 | Virtual Input 11 | 1 | Inactive | Active | |
| 20 | Virtual Input 12 | 1 | Inactive | Active | |
| 21 | Virtual Input 13 | 1 | Inactive | Active | |
| 22 | Virtual Input 14 | 1 | Inactive | Active | |
| 23 | Virtual Input 15 | 1 | Inactive | Active | |
| 24 | Virtual Input 16 | 1 | Inactive | Active | |
| 25 | Virtual Input 17 | 1 | Inactive | Active | |
| 26 | Virtual Input 18 | 1 | Inactive | Active | |
| 27 | Virtual Input 19 | 1 | Inactive | Active | |
| 28 | Virtual Input 20 | 1 | Inactive | Active | |
| 29 | Virtual Input 21 | 1 | Inactive | Active | |
| 30 | Virtual Input 22 | 1 | Inactive | Active | |
| 31 | Virtual Input 23 | 1 | Inactive | Active | |

| | | | | | |
|---|---|---|---|---|---|
| 32 | Virtual Input 24 | 1 | Inactive | Active | |
| 33 | Virtual Input 25 | 1 | Inactive | Active | |
| 34 | Virtual Input 26 | 1 | Inactive | Active | |
| 35 | Virtual Input 27 | 1 | Inactive | Active | |
| 36 | Virtual Input 28 | 1 | Inactive | Active | |
| 37 | Virtual Input 29 | 1 | Inactive | Active | |
| 38 | Virtual Input 30 | 1 | Inactive | Active | |
| 39 | Input1 50LS-1 Output | 1 | Inactive | Active | OR of Input1 50LS-1 A, B and C |
| 40 | Input1 50LS-2 Output | 1 | Inactive | Active | OR of Input1 50LS-2 A, B and C |
| 41 | Input1 50BF-1 Trip | 1 | Inactive | Active | |
| 42 | Input1 50BF-2 Trip | 1 | Inactive | Active | |
| 43 | Input1 50 Trip | 1 | Inactive | Active | OR of Input1 50 A, B and C Trip |
| 44 | Input1 51 Alarm | 1 | Inactive | Active | OR of Input1 51 A, B and C Alarm |
| 45 | Input1 51 Trip | 1 | Inactive | Active | OR of Input1 51 A, B and C Trip |
| 46 | Input1 50N Trip | 1 | Inactive | Active | |
| 47 | Input1 51N Alarm | 1 | Inactive | Active | |
| 48 | Input1 51N Trip | 1 | Inactive | Active | |
| 49 | Input1 46-50 Trip | 1 | Inactive | Active | |
| 50 | Input1 46-51 Alarm | 1 | Inactive | Active | |
| 51 | Input1 46-51 Trip | 1 | Inactive | Active | |
| 52 | Input2 50LS-1 Output | 1 | Inactive | Active | OR of Input2 50LS-1 A, B and C |
| 53 | Input2 50LS-2 Output | 1 | Inactive | Active | OR of Input2 50LS-2 A, B and C |
| 54 | Input2 50BF-1 Trip | 1 | Inactive | Active | |
| 55 | Input2 50BF-2 Trip | 1 | Inactive | Active | |
| 56 | Input2 50 Trip | 1 | Inactive | Active | OR of Input2 50 A, B and C Trip |
| 57 | Input2 51 Alarm | 1 | Inactive | Active | OR of Input2 51 A, B and C Alarm |
| 58 | Input2 51 Trip | 1 | Inactive | Active | OR of Input2 51 A, B and C Trip |
| 59 | Input2 50N Trip | 1 | Inactive | Active | |
| 60 | Input2 51N Alarm | 1 | Inactive | Active | |
| 61 | Input2 51N Trip | 1 | Inactive | Active | |

| | | | | | |
|---|---|---|---|---|---|
| 62 | Input2 46-50 Trip | 1 | Inactive | Active | |
| 63 | Input2 46-51 Alarm | 1 | Inactive | Active | |
| 64 | Input2 46-51 Trip | 1 | Inactive | Active | |
| 65 | Input3 50LS-1 Output | 1 | Inactive | Active | OR of Input3 50LS-1 A, B and C |
| 66 | Input3 50LS-2 Output | 1 | Inactive | Active | OR of Input3 50LS-2 A, B and C |
| 67 | Input3 50BF-1 Trip | 1 | Inactive | Active | |
| 68 | Input3 50BF-2 Trip | 1 | Inactive | Active | |
| 69 | Input3 50 Trip | 1 | Inactive | Active | OR of Input3 50 A, B and C Trip |
| 70 | Input3 51 Alarm | 1 | Inactive | Active | OR of Input3 51 A, B and C Alarm |
| 71 | Input3 51 Trip | 1 | Inactive | Active | OR of Input3 51 A, B and C Trip |
| 72 | Input3 50N Trip | 1 | Inactive | Active | |
| 73 | Input3 51N Alarm | 1 | Inactive | Active | |
| 74 | Input3 51N Trip | 1 | Inactive | Active | |
| 75 | Input3 46-50 Trip | 1 | Inactive | Active | |
| 76 | Input3 46-51 Alarm | 1 | Inactive | Active | |
| 77 | Input3 46-51 Trip | 1 | Inactive | Active | |
| 78 | Input4 50LS-1 Output | 1 | Inactive | Active | OR of Input4 50LS-1 A, B and C |
| 79 | Input4 50LS-2 Output | 1 | Inactive | Active | OR of Input4 50LS-2 A, B and C |
| 80 | Input4 50BF-1 Trip | 1 | Inactive | Active | |
| 81 | Input4 50BF-2 Trip | 1 | Inactive | Active | |
| 82 | Input4 50 Trip | 1 | Inactive | Active | OR of Input4 50 A, B and C Trip |
| 83 | Input4 51 Alarm | 1 | Inactive | Active | OR of Input4 51 A, B and C Alarm |
| 84 | Input4 51 Trip | 1 | Inactive | Active | OR of Input4 51 A, B and C Trip |
| 85 | Input4 50N Trip | 1 | Inactive | Active | |
| 86 | Input4 51N Alarm | 1 | Inactive | Active | |
| 87 | Input4 51N Trip | 1 | Inactive | Active | |
| 88 | Input4 46-50 Trip | 1 | Inactive | Active | |
| 89 | Input4 46-51 Alarm | 1 | Inactive | Active | |
| 90 | Input5 46-51 Trip | 1 | Inactive | Active | |

| | | | | | |
|---|---|---|---|---|---|
| 91 | Input5 50LS-1 Output | 1 | Inactive | Active | OR of Input5 50LS-1 A, B and C |
| 92 | Input5 50LS-2 Output | 1 | Inactive | Active | OR of Input5 50LS-2 A, B and C |
| 93 | Input5 50BF-1 Trip | 1 | Inactive | Active | |
| 94 | Input5 50BF-2 Trip | 1 | Inactive | Active | |
| 95 | Input5 50 Trip | 1 | Inactive | Active | OR of Input5 50 A, B and C Trip |
| 96 | Input5 51 Alarm | 1 | Inactive | Active | OR of Input5 51 A, B and C Alarm |
| 97 | Input5 51 Trip | 1 | Inactive | Active | OR of Input5 51 A, B and C Trip |
| 98 | Input5 50N Trip | 1 | Inactive | Active | |
| 99 | Input5 51N Alarm | 1 | Inactive | Active | |
| 100 | Input5 51N Trip | 1 | Inactive | Active | |
| 101 | Input5 46-50 Trip | 1 | Inactive | Active | |
| 102 | Input5 46-51 Alarm | 1 | Inactive | Active | |
| 103 | Input5 46-51 Trip | 1 | Inactive | Active | |
| 104 | Input6 50LS-1 Output | 1 | Inactive | Active | OR of Input6 50LS-1 A, B and C |
| 105 | Input6 50LS-2 Output | 1 | Inactive | Active | OR of Input6 50LS-2 A, B and C |
| 106 | Input6 50BF-1 Trip | 1 | Inactive | Active | |
| 107 | Input6 50BF-2 Trip | 1 | Inactive | Active | |
| 108 | Input6 50 Trip | 1 | Inactive | Active | OR of Input6 50 A, B and C Trip |
| 109 | Input6 51 Alarm | 1 | Inactive | Active | OR of Input6 51 A, B and C Alarm |
| 110 | Input6 51 Trip | 1 | Inactive | Active | OR of Input6 51 A, B and C Trip |
| 111 | Input6 50N Trip | 1 | Inactive | Active | |
| 112 | Input6 51N Alarm | 1 | Inactive | Active | |
| 113 | Input6 51N Trip | 1 | Inactive | Active | |
| 114 | Input6 46-50 Trip | 1 | Inactive | Active | |
| 115 | Input6 46-51 Alarm | 1 | Inactive | Active | |
| 116 | Input6 46-51 Trip | 1 | Inactive | Active | |
| 117 | 87T Trip | 1 | Inactive | Active | OR of 87T A, B and C Trip |
| 118 | 87B-1 Trip | 1 | Inactive | Active | OR of 87B-1 A, B and C Trip |
| 119 | 59 -1Trip | 1 | Inactive | Active | OR of 59-1 A, B and C Trip |
| 120 | 59-2 Trip | 1 | Inactive | Active | OR of 59-2 A, B and C Trip |

| | | | | | |
|---|---|---|---|---|---|
| 121 | 27-1 Trip | 1 | Inactive | Active | OR of 27-1 A, B and C Trip |
| 122 | 27-2 Trip | 1 | Inactive | Active | OR of 27-2 A, B and C Trip |
| 123 | 60 Alarm | 1 | Inactive | Active | OR of 60 A, B and C Alarm |
| 124 | 81O-1 Trip | 1 | Inactive | Active | |
| 125 | 81O-2 Trip | 1 | Inactive | Active | |
| 126 | 81U-1 Trip | 1 | Inactive | Active | |
| 127 | 81U-2 Trip | 1 | Inactive | Active | |
| 128 | Self Check fail | 1 | Inactive | Active | |
| 129 | ProLogic1 | 1 | Inactive | Active | |
| 130 | ProLogic2 | 1 | Inactive | Active | |
| 131 | ProLogic3 | 1 | Inactive | Active | |
| 132 | ProLogic4 | 1 | Inactive | Active | |
| 133 | ProLogic5 | 1 | Inactive | Active | |
| 134 | ProLogic6 | 1 | Inactive | Active | |
| 135 | ProLogic7 | 1 | Inactive | Active | |
| 136 | ProLogic8 | 1 | Inactive | Active | |
| 137 | ProLogic9 | 1 | Inactive | Active | |
| 138 | ProLogic10 | 1 | Inactive | Active | |
| 139 | ProLogic11 | 1 | Inactive | Active | |
| 140 | ProLogic12 | 1 | Inactive | Active | |
| 141 | ProLogic13 | 1 | Inactive | Active | |
| 142 | ProLogic14 | 1 | Inactive | Active | |
| 143 | ProLogic15 | 1 | Inactive | Active | |
| 144 | 87T Restraint | 1 | Inactive | Active | |
| 145 | 87T Unrestrained | 1 | Inactive | Active | |
| 146 | 87B-1 Unrestrained | 1 | Inactive | Active | |
| 147 | 87B-1 Block via Saturation | 1 | Inactive | Active | |
| 148 | 87B-2 Trip | 1 | Inactive | Active | OR of 87B-2 A, B and C Trip |
| 149 | 87B-2 Unrestrained | 1 | Inactive | Active | |
| 150 | 87B-2 Block via Saturation | 1 | Inactive | Active | |
| 151* | Output Contact 1 | 1 | Open | Closed | |
| 152* | Output Contact 2 | 1 | Open | Closed | |
| 153* | Output Contact 3 | 1 | Open | Closed | |
| 154* | Output Contact 4 | 1 | Open | Closed | |

| | | | | | |
|---|---|---|---|---|---|
| 155* | Output Contact 5 | 1 | Open | Closed | |
| 156* | Output Contact 6 | 1 | Open | Closed | |
| 157* | Output Contact 7 | 1 | Open | Closed | |
| 158* | Output Contact 8 | 1 | Open | Closed | |
| 159* | Output Contact 9 | 1 | Open | Closed | |
| 160* | Output Contact 10 | 1 | Open | Closed | |
| 161* | Output Contact 11 | 1 | Open | Closed | |
| 162* | Output Contact 12 | 1 | Open | Closed | |
| 163* | Output Contact 13 | 1 | Open | Closed | |
| 164* | Output Contact 14 | 1 | Open | Closed | |
| 165* | 87T A Trip | 1 | Inactive | Active | |
| 166* | 87T B Trip | 1 | Inactive | Active | |
| 167* | 87T C Trip | 1 | Inactive | Active | |
| 168* | 87T Unrestrained A | 1 | Inactive | Active | |
| 169* | 87T Unrestrained B | 1 | Inactive | Active | |
| 170* | 87T Unrestrained C | 1 | Inactive | Active | |
| 171* | 87B-1 A Trip | 1 | Inactive | Active | |
| 172* | 87B-1 B Trip | 1 | Inactive | Active | |
| 173* | 87B-1 C Trip | 1 | Inactive | Active | |
| 174* | 87B-1 Unrestrained A | 1 | Inactive | Active | |
| 175* | 87B-1 Unrestrained B | 1 | Inactive | Active | |
| 176* | 87B-1 Unrestrained C | 1 | Inactive | Active | |
| 177* | 87B-2 A Trip | 1 | Inactive | Active | |
| 178* | 87B-2 B Trip | 1 | Inactive | Active | |
| 179* | 87B-2 C Trip | 1 | Inactive | Active | |
| 180* | 87B-2 Unrestrained A | 1 | Inactive | Active | |
| 181* | 87B-2 Unrestrained B | 1 | Inactive | Active | |
| 182* | 87B-2 Unrestrained C | 1 | Inactive | Active | |
| 183* | 59-1 A Trip | 1 | Inactive | Active | |
| 184* | 59-1 B Trip | 1 | Inactive | Active | |
| 185* | 59-1 C Trip | 1 | Inactive | Active | |
| 186* | 59-2 A Trip | 1 | Inactive | Active | |
| 187* | 59-2 B Trip | 1 | Inactive | Active | |
| 188* | 59-2 C Trip | 1 | Inactive | Active | |
| 189* | 27-1 A Trip | 1 | Inactive | Active | |
| 190* | 27-1 B Trip | 1 | Inactive | Active | |

| | | | | | |
|---|---|---|---|---|---|
| 191* | 27-1 C Trip | 1 | Inactive | Active | |
| 192* | 27-2 A Trip | 1 | Inactive | Active | |
| 193* | 27-2 B Trip | 1 | Inactive | Active | |
| 194* | 27-2 C Trip | 1 | Inactive | Active | |
| 195* | 60 A Alarm | 1 | Inactive | Active | |
| 196* | 60 B Alarm | 1 | Inactive | Active | |
| 197* | 60 C Alarm | 1 | Inactive | Active | |
| 198* | Input1 50LS-1 A Output | 1 | Inactive | Active | |
| 199* | Input1 50LS-1 B Output | 1 | Inactive | Active | |
| 200* | Input1 50LS-1 C Output | 1 | Inactive | Active | |
| 201* | Input1 50LS-2 A Output | 1 | Inactive | Active | |
| 202* | Input1 50LS-2 B Output | 1 | Inactive | Active | |
| 203* | Input1 50LS-2 C Output | 1 | Inactive | Active | |
| 204* | Input1 50 A Trip | 1 | Inactive | Active | |
| 205* | Input1 50 B Trip | 1 | Inactive | Active | |
| 206* | Input1 50 C Trip | 1 | Inactive | Active | |
| 207* | Input1 51 A Alarm | 1 | Inactive | Active | |
| 208* | Input1 51 B Alarm | 1 | Inactive | Active | |
| 209* | Input1 51 C Alarm | 1 | Inactive | Active | |
| 210* | Input1 51 A Trip | 1 | Inactive | Active | |
| 211* | Input1 51 B Trip | 1 | Inactive | Active | |
| 212* | Input1 51 C Trip | 1 | Inactive | Active | |
| 213* | Input2 50LS-1 A Output | 1 | Inactive | Active | |
| 214* | Input2 50LS-1 B Output | 1 | Inactive | Active | |
| 215* | Input2 50LS-1 C Output | 1 | Inactive | Active | |
| 216* | Input2 50LS-2 A Output | 1 | Inactive | Active | |
| 217* | Input2 50LS-2 B Output | 1 | Inactive | Active | |
| 218* | Input2 50LS-2 C Output | 1 | Inactive | Active | |
| 219* | Input2 50 A Trip | 1 | Inactive | Active | |
| 220* | Input2 50 B Trip | 1 | Inactive | Active | |
| 221* | Input2 50 C Trip | 1 | Inactive | Active | |
| 222* | Input2 51 A Alarm | 1 | Inactive | Active | |
| 223* | Input2 51 B Alarm | 1 | Inactive | Active | |
| 224* | Input2 51 C Alarm | 1 | Inactive | Active | |
| 225* | Input2 51 A Trip | 1 | Inactive | Active | |
| 226* | Input2 51 B Trip | 1 | Inactive | Active | |

| | | | | | |
|---|---|---|---|---|---|
| 227* | Input2 51 C Trip | 1 | Inactive | Active | |
| 228* | Input3 50LS-1 A Output | 1 | Inactive | Active | |
| 229* | Input3 50LS-1 B Output | 1 | Inactive | Active | |
| 230* | Input3 50LS-1 C Output | 1 | Inactive | Active | |
| 231* | Input3 50LS-2 A Output | 1 | Inactive | Active | |
| 232* | Input3 50LS-2 B Output | 1 | Inactive | Active | |
| 233* | Input3 50LS-2 C Output | 1 | Inactive | Active | |
| 234* | Input3 50 A Trip | 1 | Inactive | Active | |
| 235* | Input3 50 B Trip | 1 | Inactive | Active | |
| 236* | Input3 50 C Trip | 1 | Inactive | Active | |
| 237* | Input3 51 A Alarm | 1 | Inactive | Active | |
| 238* | Input3 51 B Alarm | 1 | Inactive | Active | |
| 239* | Input3 51 C Alarm | 1 | Inactive | Active | |
| 240* | Input3 51 A Trip | 1 | Inactive | Active | |
| 241* | Input3 51 B Trip | 1 | Inactive | Active | |
| 242* | Input3 51 C Trip | 1 | Inactive | Active | |
| 243* | Input4 50LS-1 A Output | 1 | Inactive | Active | |
| 244* | Input4 50LS-1 B Output | 1 | Inactive | Active | |
| 245* | Input4 50LS-1 C Output | 1 | Inactive | Active | |
| 246* | Input4 50LS-2 A Output | 1 | Inactive | Active | |
| 247* | Input4 50LS-2 B Output | 1 | Inactive | Active | |
| 248* | Input4 50LS-2 C Output | 1 | Inactive | Active | |
| 249* | Input4 50 A Trip | 1 | Inactive | Active | |
| 250* | Input4 50 B Trip | 1 | Inactive | Active | |
| 251* | Input4 50 C Trip | 1 | Inactive | Active | |
| 252* | Input4 51 A Alarm | 1 | Inactive | Active | |
| 253* | Input4 51 B Alarm | 1 | Inactive | Active | |
| 254* | Input4 51 C Alarm | 1 | Inactive | Active | |
| 255* | Input4 51 A Trip | 1 | Inactive | Active | |
| 256* | Input4 51 B Trip | 1 | Inactive | Active | |
| 257* | Input4 51 C Trip | 1 | Inactive | Active | |
| 258* | Input5 50LS-1 A Output | 1 | Inactive | Active | |
| 259* | Input5 50LS-1 B Output | 1 | Inactive | Active | |
| 260* | Input5 50LS-1 C Output | 1 | Inactive | Active | |
| 261* | Input5 50LS-2 A Output | 1 | Inactive | Active | |
| 262* | Input5 50LS-2 B Output | 1 | Inactive | Active | |

| | | | | | |
|---|---|---|---|---|---|
| 263* | Input5 50LS-2 C Output | 1 | Inactive | Active | |
| 264* | Input5 50 A Trip | 1 | Inactive | Active | |
| 265* | Input5 50 B Trip | 1 | Inactive | Active | |
| 266* | Input5 50 C Trip | 1 | Inactive | Active | |
| 267* | Input5 51 A Alarm | 1 | Inactive | Active | |
| 268* | Input5 51 B Alarm | 1 | Inactive | Active | |
| 269* | Input5 51 C Alarm | 1 | Inactive | Active | |
| 270* | Input5 51 A Trip | 1 | Inactive | Active | |
| 271* | Input5 51 B Trip | 1 | Inactive | Active | |
| 272* | Input5 51 C Trip | 1 | Inactive | Active | |
| 273* | Input6 50LS-1 A Output | 1 | Inactive | Active | |
| 274* | Input6 50LS-1 B Output | 1 | Inactive | Active | |
| 275* | Input6 50LS-1 C Output | 1 | Inactive | Active | |
| 276* | Input6 50LS-2 A Output | 1 | Inactive | Active | |
| 277* | Input6 50LS-2 B Output | 1 | Inactive | Active | |
| 278* | Input6 50LS-2 C Output | 1 | Inactive | Active | |
| 279* | Input6 50 A Trip | 1 | Inactive | Active | |
| 280* | Input6 50 B Trip | 1 | Inactive | Active | |
| 281* | Input6 50 C Trip | 1 | Inactive | Active | |
| 282* | Input6 51 A Alarm | 1 | Inactive | Active | |
| 283* | Input6 51 B Alarm | 1 | Inactive | Active | |
| 284* | Input6 51 C Alarm | 1 | Inactive | Active | |
| 285* | Input6 51 A Trip | 1 | Inactive | Active | |
| 286* | Input6 51 B Trip | 1 | Inactive | Active | |
| 287* | Input6 51 C Trip | 1 | Inactive | Active | |
| 288* | IRIG-B Signal loss | 1 | Inactive | Active | |

| **2.2 Binary Output Status And Control Relay Output Block** | **Capabilities** | **Current Value** | **If configurable, list methods** |
|---|---|---|---|
| 2.2.1 Minimum pulse time allowed with Trip, Close, and Pulse On commands: | ☒ Fixed at 0.000 ms (hardware may limit this further)<br>☐ Based on point Index (add column to table below) | | |
| 2.2.2 Maximum pulse time allowed with Trip, Close, and Pulse On commands: | ☒ Fixed at 0.000 ms (hardware may limit this further)<br>☐ Based on point Index (add column to table below) | | |
| 2.2.3 Binary Output Status included in Class 0 response: | ☒ Always<br>☐ Never<br>☐ Only if point is assigned to Class 1, 2, or 3<br>☐ Based on point Index (add column to table below) | | |
| 2.2.4 Reports Output Command Event Objects: | ☒ Never<br>☐ Only upon a successful Control<br>☐ Upon all control attempts | Not supported | |
| 2.2.5 Event Variation reported when variation 0 requested: | ☐ Variation 1 - without time<br>☐ Variation 2 - with absolute time<br>☐ Based on point Index (add column to table below) | Not supported | B-PRO Offliner (See Note 2 below) |
| 2.2.6 Command Event Variation reported when variation 0 requested: | ☐ Variation 1 - without time<br>☐ Variation 2 - with absolute time<br>☐ Based on point Index (add column to table below) | Not supported | B-PRO Offliner (See Note 2 below) |
| 2.2.7 Event reporting mode: | ☐ Only most recent<br>☐ All events | Not supported | B-PRO Offliner (See Note 2 below) |
| 2.2.8 Command Event reporting mode: | ☐ Only most recent<br>☐ All events | Not supported | |
| 2.2.9 Maximum Time between Select and Operate: | ☐ Not Applicable<br>☒ Fixed at 10 seconds<br>☐ Configurable, range ______ to ______ seconds<br>☐ Configurable, selectable from___,___,___seconds<br>☐ Configurable, other, describe______________<br>☐ Variable, explain ______________________<br>☐ Based on point Index (add column to table below) | 10 s | |
| 2.2.10 Definition of Binary Output Status/Control relay output block (CROB) Point List: | ☐ Fixed, list shown in table below<br>☒ Configurable<br>☐ Other, explain_____________________ | Complete list is shown in the table below; points excluded from the default configuration are marked with * | B-PRO Offliner |

| | |
|---|---|
| **NOTES** | 1. Binary Outputs are scanned with 500 ms resolution.<br><br>2. Events are not supported for Binary Outputs (group 10), but most of Binary Output points can be mapped to Binary Inputs (group 2) with full Event and Class Data support. See B-PRO Offliner/DNP Configuration/Point Map screen for complete point lists and configuration options.<br><br>3. Virtual Inputs (default Binary Output points 14-43) can be used to control relay output contacts. See B-PRO Offliner Output Matrix screen for configuration options.<br><br>4. Binary Output data points are user selectable; the data points available in the device for any given Binary Output point selection can be obtained through the B-PRO Offliner software (see SCADA Setting Summary). |

| Point Index | Name | Supported Control Operations | | | | | | | | | | | Name for State when value is 0 | Name for State when value is 1 | Default Class Assigned to Events (1, 2, 3 or none) | | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Select/Operate | Direct Operate | Direct Operate - No Ack | Pulse On / NUL | Pulse Off | Latch On / NUL | Latch Off / NUL | Trip | Close | Count > 1 | Cancel Currently Running Operation | | | Change | Command | |
| 0 | Output contact 1 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 1 | Output contact 2 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 2 | Output contact 3 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 3 | Output contact 4 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 4 | Output contact 5 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 5 | Output contact 6 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 6 | Output contact 7 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 7 | Output contact 8 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 8 | Output contact 9 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 9 | Output contact 10 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 10 | Output contact 11 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 11 | Output contact 12 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 12 | Output contact 13 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 13 | Output contact 14 | - | - | - | - | - | - | - | - | - | - | - | Open | Closed | None | None | |
| 14 | Virtual Input 1 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 15 | Virtual Input 2 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 16 | Virtual Input 3 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 17 | Virtual Input 4 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 18 | Virtual Input 5 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 19 | Virtual Input 6 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 20 | Virtual Input 7 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 21 | Virtual Input 8 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |

| Point Index | Name | Supported Control Operations | | | | | | | | | | | Name for State when value is 0 | Name for State when value is 1 | Default Class Assigned to Events (1, 2, 3 or none) | | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Select/Operate | Direct Operate | Direct Operate - No Ack | Pulse On / NUL | Pulse Off | Latch On / NUL | Latch Off / NUL | Trip | Close | Count > 1 | Cancel Currently Running Operation | | | Change | Command | |
| 22 | Virtual Input 9 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 23 | Virtual Input 10 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 24 | Virtual Input 11 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 25 | Virtual Input 12 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 26 | Virtual Input 13 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 27 | Virtual Input 14 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 28 | Virtual Input 15 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 29 | Virtual Input 16 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 30 | Virtual Input 17 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 31 | Virtual Input 18 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 32 | Virtual Input 19 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 33 | Virtual Input 20 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 34 | Virtual Input 21 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 35 | Virtual Input 22 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 36 | Virtual Input 23 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 37 | Virtual Input 24 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 38 | Virtual Input 25 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 39 | Virtual Input 26 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 40 | Virtual Input 27 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 41 | Virtual Input 28 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 42 | Virtual Input 29 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |
| 43 | Virtual Input 30 | Y | Y | Y | Y | - | Y | Y | - | - | - | - | Inactive | Active | None | None | Pulse duration fixed at 1 s |

| **2.3 Analog Input Points** | **Capabilities** | **Current Value** | **If configurable, list methods** |
|---|---|---|---|
| 2.3.1 Static Variation reported when variation 0 requested: | ☐ Variation 1 - 32-bit with flag<br>☐ Variation 2 - 16-bit with flag<br>☐ Variation 3 - 32-bit without flag<br>☒ Variation 4 - 16-bit without flag<br>☐ Variation 5 - single-precision floating point with flag<br>☐ Variation 6 - double-precision floating point with flag<br>☐ Based on point Index (add column to table below) | | |
| 2.3.2 Event Variation reported when variation 0 requested: | ☐ Variation 1 - 32-bit without time<br>☒ Variation 2 - 16-bit without time<br>☐ Variation 3 - 32-bit with time<br>☐ Variation 4 - 16-bit with time<br>☐ Variation 5 - single-precision floating point w/o time<br>☐ Variation 6 - double-precision floating point w/o time<br>☐ Variation 7 - single-precision floating point with time<br>☐ Variation 8 - double-precision floating point with time<br>☐ Based on point Index (add column to table below) | | |
| 2.3.3 Event reporting mode: | ☐ Only most recent<br>☒ All events | | |
| 2.3.4 Analog Inputs Included in Class 0 response: | ☒ Always<br>☐ Never<br>☐ Only if point is assigned to Class 1, 2, or 3<br>☐ Based on point Index (add column to table below) | | |
| 2.3.5 How Deadbands are set: | ☐ A. Global Fixed<br>☐ B. Configurable through DNP<br>☒ C. Configurable via other means<br>☐ D. Other, explain ________________________<br>☐ Based on point Index - column specifies which of the options applies, B, C, or D | | B-PRO Offliner |
| 2.3.6 Analog Deadband Algorithm:<br>simple - just compares the difference from the previous reported value | ☒ Simple<br>☐ Integrating<br>☐ Other, explain __________________________ | | |
| 2.3.7 Definition of Analog Input Point List: | ☐ Fixed, list shown in table below<br>☒ Configurable<br>☐ Other, explain_____________________ | Default list is shown in table below | B-PRO Offliner |

| NOTES | 1. Analog Inputs are scanned with 500 ms resolution.<br><br>2. Nominal values in calculations for the following table are based on 69V secondary voltage * PT ratio for voltage channels, and either 1 A or 5A secondary current * CT ratio for current channels dependent upon the format of CT installed in the B-PRO.<br><br>3. Analog Input data points are user selectable; the data points available in the device for any given Analog Input point selection can be obtained through the B-PRO Offliner software (see SCADA Setting Summary). |
|---|---|

| Point Index | Name | Default Class Assigned to Events (1, 2, 3 or none) | Transmitted Value[a] | | Scaling[b] | | Units | Resolution[c] (default/ maximal) | Description |
|---|---|---|---|---|---|---|---|---|---|
| | | | Minimum[c] | Maximum[d] | Multiplier (default/ (range)) | Offset | | | |
| 0 | Va Magnitude | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | KV | 0.1 / 0.00001 | |
| 1 | Va Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 2 | Vb Magnitude | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | KV | 0.1 / 0.00001 | |
| 3 | Vb Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 4 | Vc Magnitude | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | KV | 0.1 / 0.00001 | |
| 5 | Vc Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 6 | I1a Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 7 | I1a Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 8 | I1b Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 9 | I1b Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 10 | I1c Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 11 | I1c Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 12 | I2a Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 13 | I2a Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 14 | I2b Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 15 | I2b Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 16 | I2c Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 17 | I2c Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 18 | I3a Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 19 | I3a Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 20 | I3b Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 21 | I3b Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 22 | I3c Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 23 | I3c Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 24 | I4a Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 25 | I4a Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 26 | I4b Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 27 | I4b Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 28 | I4c Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 29 | I4c Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 30 | I5a Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 31 | I5a Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 32 | I5b Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |

| Point Index | Name | Default Class Assigned to Events (1, 2, 3 or none) | Transmitted Value[a] | | Scaling[b] | | Units | Resolution[c] (default/ maximal) | Description |
|---|---|---|---|---|---|---|---|---|---|
| | | | Minimum[c] | Maximum[d] | Multiplier (default/ (range)) | Offset | | | |
| 33 | I5b Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 34 | I5c Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 – 1000) | 0.0 | A | 1.0 / 0.01 | |
| 35 | I5c Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 36 | I6ca Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 – 1000) | 0.0 | A | 1.0 / 0.01 | |
| 37 | I6a Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 38 | I6b Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 – 1000) | 0.0 | A | 1.0 / 0.01 | |
| 39 | I6b Angle | 2 | -18,000 | 18,000 | 0.1 / (0.01 - 1.0) | 0.0 | degrees | 0.1 / 0.01 | |
| 40 | I6c Magnitude | 2 | 0 | Configurable | 1.0 / (0.01 – 1000) | 0.0 | A | 1.0 / 0.01 | |
| 41 | I6c Angle | 2 | -18,000 | 18,000 | | 0.1 / (0.01 - 1.0) | NA | NA | |
| 42 | 87T Ia Operating | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 43 | 87T Ib Operating | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 44 | 87T Ic Operating | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 45 | 87T Ia Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 46 | 87T Ib Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 47 | 87T Ic Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 48 | 87B-1 Ia Operating | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 49 | 87B-1 Ib Operating | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 50 | 87B-1 Ic Operating | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 51 | 87B-1 Ia Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 52 | 87B-1 Ib Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 53 | 87B-1 Ic Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 54 | Input 1 P | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | MW | 0.1 / 0.00001 | |
| 55 | Input 1 Q | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | Mvar | 0.1 / 0.00001 | |
| 56 | Input 2 P | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | MW | 0.1 / 0.00001 | |
| 57 | Input 2 Q | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | Mvar | 0.1 / 0.00001 | |
| 58 | Input 3 P | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | MW | 0.1 / 0.00001 | |
| 59 | Input 3 Q | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | Mvar | 0.1 / 0.00001 | |
| 60 | Input 4 P | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | MW | 0.1 / 0.00001 | |
| 61 | Input 4 Q | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | Mvar | 0.1 / 0.00001 | |
| 62 | Input 5 P | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | MW | 0.1 / 0.00001 | |
| 63 | Input 5 Q | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | Mvar | 0.1 / 0.00001 | |
| 64 | Input 6 P | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | MW | 0.1 / 0.00001 | |
| 65 | Input 6 Q | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | Mvar | 0.1 / 0.00001 | |
| 66 | Pos Seq Voltage | 2 | 0 | Configurable | 0.1 / (0.00001- 1.0) | 0.0 | KV | 0.1 / 0.00001 | |
| 67 | Pos Seq Fre-quency | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | Hz | 0.01 / 0.001 | |
| 68 | 87B-2 Ia Operating | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 69 | 87B-2 Ib Operat-ing | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 70 | 87B-2 Ic Operating | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 71 | 87B-2 Ia Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 72 | 87B-2 Ib Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 73 | 87B-2 Ic Restraint | 2 | 0 | Configurable | 1.0 / (0.01 - 1000) | 0.0 | A | 1.0 / 0.01 | |
| 74 | Self check Fail | 2 | 0 | Configurable | 1.0 / fixed | 0.0 | NA | 1.0 / 1.0 | |

a. The minimum and maximum transmitted values are the lowest and highest values that the outstation will report in DNP analog input objects. These values are integers if the outstation transmits only integers. If the outstation is capable of transmitting both integers and floating-point, then integer and floating-point values are required for the minimums and maximums.
For example, a pressure sensor is able to measure 0 to 500 kPa. The outstation provides a linear conversion of the sensor's output signal to integers in the range of 0 to 25000 or floating-point values of 0 to 500.000. The sensor and outstation are used in an application where the maximum possible pressure is 380 kPa. For this input, the minimum transmitted value would be stated as 0 / 0.0 and the maximum transmitted value would be stated as 19000 / 380.000.
b. The scaling information for each point specifies how data transmitted in integer variations (16 bit and 32 bit) is converted to engineering units when received by the Master (i.e. scaled according to the equation: scaled value = multiplier * raw + offset). Scaling is not applied to Floating point variations since they are already transmitted in engineering units.
c. Resolution is the smallest change that may be detected in the value due to quantization errors and is given in the units shown in the previous column. This parameter does not represent the accuracy of the measurement.
d. Maximal values are calculated as (2 * Configured Nominal / Multiplier) for voltage channels and as (40 * Configured Nominal / Multiplier) for current channels (see Note 2 above for the nominal definitions).

| **2.4 Octet String Points** | **Capabilities** | **Current Value** | **If configurable, list methods** |
|---|---|---|---|
| 2.4.1 Event reporting mode *: | ☐ Only most recent<br>☒ All events | | |
| 2.4.2 Octet Strings Included in Class 0 response: | ☐ Always<br>☒ Never<br>☐ Only if point is assigned to Class 1, 2, or 3<br>☐ Based on point Index (add column to table below) | | |
| 2.4.3 Definition of Octet String Point List: | ☐ Fixed, list shown in table below<br>☐ Configurable (current list may be shown in table below)<br>☒ Other, explain Used for Event Log access as described below | | |

* Object 110 and 111 are Octet String Object used to provide access to the Event Log text of the relay. Object 110 always contains the most recent event in the relay. Object 111 is the corresponding change event object.

As stated in the DNP specifications, the variation of the response object represents the length of the string. The string represents the ASCII values of the event text. The following example shows an event returned through either of the octet string objects:

Event Message:

| 1999Dec08 07:27:55.248 : 27-2 (U/V) on ABC: Trip |
|---|

| DNP Octet string object components: | | | | | |
|---|---|---|---|---|---|
| 0x20 | 0x20 | 0x31 | 0x39 | 0x39 | 0x39 |
| 0x44 | 0x65 | 0x63 | 0x30 | 0x38 | 0x20 |
| 0x30 | 0x37 | 0x3A | 0x32 | 0x37 | 0x3A |
| 0x35 | 0x35 | 0x2E | 0x32 | 0x34 | 0x38 |
| 0x20 | 0x3A | 0x20 | 0x32 | 0x37 | 0x2D |
| 0x32 | 0x20 | 0x28 | 0x55 | 0x2F | 0x56 |
| 0x29 | 0x20 | 0x6F | 0x6E | 0x20 | 0x41 |
| 0x42 | 0x43 | 0x3A | 0x20 | 0x54 | 0x72 |
| 0x69 | 0x70 | | | | |

## Implementation Table

The following implementation table identifies which object groups and variations, function codes and qualifiers the device supports in both requests and responses. The Request columns identify all requests that are parsed by an Outstation. The Response columns identify all responses that may be sent by an Outstation.

| | |
|---|---|
| **NOTES** | The implementation table lists all functionality required by the device (Outstation) as defined within the DNP3 IED Conformance Test Procedures. Any functionality beyond the highest subset level supported is indicated by highlighted rows. Any Object Groups not provided by an outstation are indicated by ~~strike-through~~ (note these Object Groups will still be parsed). |

| DNP Object Group & Variation | | | Request<br>Outstation parses | | Response<br>Outstation can issue | |
|---|---|---|---|---|---|---|
| **Group Num** | **Var Num** | **Description** | **Function Codes (dec)** | **Qualifier Codes (hex)** | **Function Codes (dec)** | **Qualifier Codes (hex)** |
| 1 | 0 | Binary Input - Any Variation | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 1 | 1 | Binary Input - Packed format | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 1 | 2 | Binary Input - With flags | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 2 | 0 | Binary Input Event - Any Variation | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response) | 17, 28 (index) |
| 2 | 1 | Binary Input Event - Without time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response)<br>~~130 (unsol. resp)~~ | 17, 28 (index) |
| 2 | 2 | Binary Input Event - With absolute time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response)<br>~~130 (unsol. resp)~~ | 17, 28 (index) |
| 2 | 3 | Binary Input Event - With relative time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response)<br>~~130 (unsol. resp)~~ | 17, 28 (index) |
| 10 | 0 | Binary Output - Any Variation | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 10 | 2 | Binary Output - Output Status with flag | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 12 | 1 | Binary Command - Control relay output block (CROB) | 3 (select)<br>4 (operate)<br>5 (direct op)<br>6 (dir. op, no ack) | 17, 28 (index) | 129 (response) | Echo of request |
| 20 | 0 | ~~Counter - Any Variation~~ | 1 (read)<br>7 (freeze)<br>8 ( freeze noack)<br>9 (freeze clear)<br>10 (frz. cl. noack) | 06 (no range, or all) | 129 (response) | |

| DNP Object Group & Variation | | | Request<br>Outstation parses | | Response<br>Outstation can issue | |
|---|---|---|---|---|---|---|
| **Group Num** | **Var Num** | **Description** | **Function Codes (dec)** | **Qualifier Codes (hex)** | **Function Codes (dec)** | **Qualifier Codes (hex)** |
| 20 | 1 | ~~Counter - 32 bit with flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |
| 20 | 2 | ~~Counter - 16 bit with flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |
| 20 | 5 | ~~Counter - 32 bit without flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |
| 20 | 6 | ~~Counter - 16 bit without flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |
| 21 | 0 | ~~Frozen Counter - Any Variation~~ | 1 (read) | 06 (no range, or all) | | |
| 21 | 1 | ~~Frozen Counter - 32 bit with flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |
| 21 | 2 | ~~Frozen Counter - 16 bit with flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |
| 21 | 9 | ~~Frozen Counter - 32 bit without flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |
| 21 | 10 | ~~Frozen Counter - 16 bit without flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |
| 22 | 0 | ~~Counter Event - Any Variation~~ | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | | |
| 22 | 1 | ~~Counter Event - 32 bit with flag~~ | | | 129 (response)<br>~~130 (unsol. resp)~~ | ~~17, 28 (index)~~ |
| 22 | 2 | ~~Counter Event - 16 bit with flag~~ | | | 129 (response)<br>~~130 (unsol. resp)~~ | ~~17, 28 (index)~~ |
| 30 | 0 | Analog Input - Any Variation | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 30 | 1 | Analog Input - 32-bit with flag | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 30 | 2 | Analog Input - 16-bit with flag | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 30 | 3 | Analog Input - 32-bit without flag | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 30 | 4 | Analog Input - 16-bit without flag | 1 (read) | 06 (no range, or all)<br>00, 01 (start-stop)<br>07, 08 (limited qty)<br>17, 28 (index) | 129 (response) | 00, 01 (start-stop) |
| 32 | 0 | Analog Input Event - Any Variation | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response) | 17, 28 (index) |
| 32 | 1 | Analog Input Event - 32-bit without time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response)<br>~~130 (unsol. resp)~~ | 17, 28 (index) |
| 32 | 2 | Analog Input Event - 16-bit without time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response)<br>~~130 (unsol. resp)~~ | 17, 28 (index) |
| 32 | 3 | Analog Input Event - 32-bit with time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response) | 17, 28 (index) |
| 32 | 4 | Analog Input Event - 16-bit with time | 1 (read) | 06 (no range, or all)<br>07, 08 (limited qty) | 129 (response) | 17, 28 (index) |
| 40 | 0 | ~~Analog Output Status - Any Variation~~ | 1 (read) | 06 (no range, or all) | 129 (response) | |
| 40 | 2 | ~~Analog Output Status - 16 bit with flag~~ | | | 129 (response) | ~~00, 01 (start-stop)~~ |

| DNP Object Group & Variation | | | Request<br>Outstation parses | | Response<br>Outstation can issue | |
|---|---|---|---|---|---|---|
| **Group Num** | **Var Num** | **Description** | **Function Codes (dec)** | **Qualifier Codes (hex)** | **Function Codes (dec)** | **Qualifier Codes (hex)** |
| 41 | 2 | ~~Analog Output - 16-bit~~ | 3 (select)<br>4 (operate)<br>5 (direct op)<br>6 (dir. op, no ack) | 17, 28 (index) | 129 (response) | ~~Echo of request~~ |
| 50 | 1 | ~~Time and Date - Absolute time~~ | 2 (write) | 07 (limited qty = 1) | 129 (response) | |
| 51 | 1 | ~~Time and Date CTO - Absolute time, synchronized~~ | | | ~~129 (response)~~<br>~~130 (unsol. resp)~~ | ~~07 (limited qty)~~<br>~~(qty = 1)~~ |
| 51 | 2 | Time and Date CTO - Absolute time, unsynchronized | | | 129 (response)<br>~~130 (unsol. resp)~~ | 07 (limited qty)<br>(qty = 1) |
| 52 | 1 | Time Delay - Coarse | | | 129 (response) | 07 (limited qty)<br>(qty = 1) |
| 52 | 2 | ~~Time delay - Fine~~ | | | ~~129 (response)~~ | ~~07 (limited qty)~~<br>~~(qty = 1)~~ |
| 60 | 1 | Class Objects - Class 0 data | 1 (read) | 06 (no range, or all) | 129 (response) | 00, 01 (start-stop) |
| 60 | 2 | Class Objects - Class 1 data | 1 (read) | 06 (no range, or all) | 129 (response) | 17, 28 (index) |
| 60 | 3 | Class Objects - Class 2 data | 1 (read) | 06 (no range, or all) | 129 (response) | 17, 28 (index) |
| 60 | 4 | Class Objects - Class 3 data | 1 (read) | 06 (no range, or all) | 129 (response) | 17, 28 (index) |
| 80 | 1 | Internal Indications - Packet format | 2 (write) | 00 (start-stop)<br>(index = 7) | 129 (response) | |
| 110 | 0 | Octet string | 1 (read) | 06 (no range, or all) | 129 (response) | 07 (limited qty) |
| 111 | 0 | Octet string event | 1 (read) | 06 (no range, or all) | 129 (response) | 07 (limited qty) |
| No Object (function code only) | | | 13 (cold restart) | | 129 (response) | |
| No Object (function code only) | | | 14 (warm restart) | | 129 (response) | |
| No Object (function code only) | | | 23 (delay meas.) | | 129 (response) | |

# Appendix G Mechanical Drawings

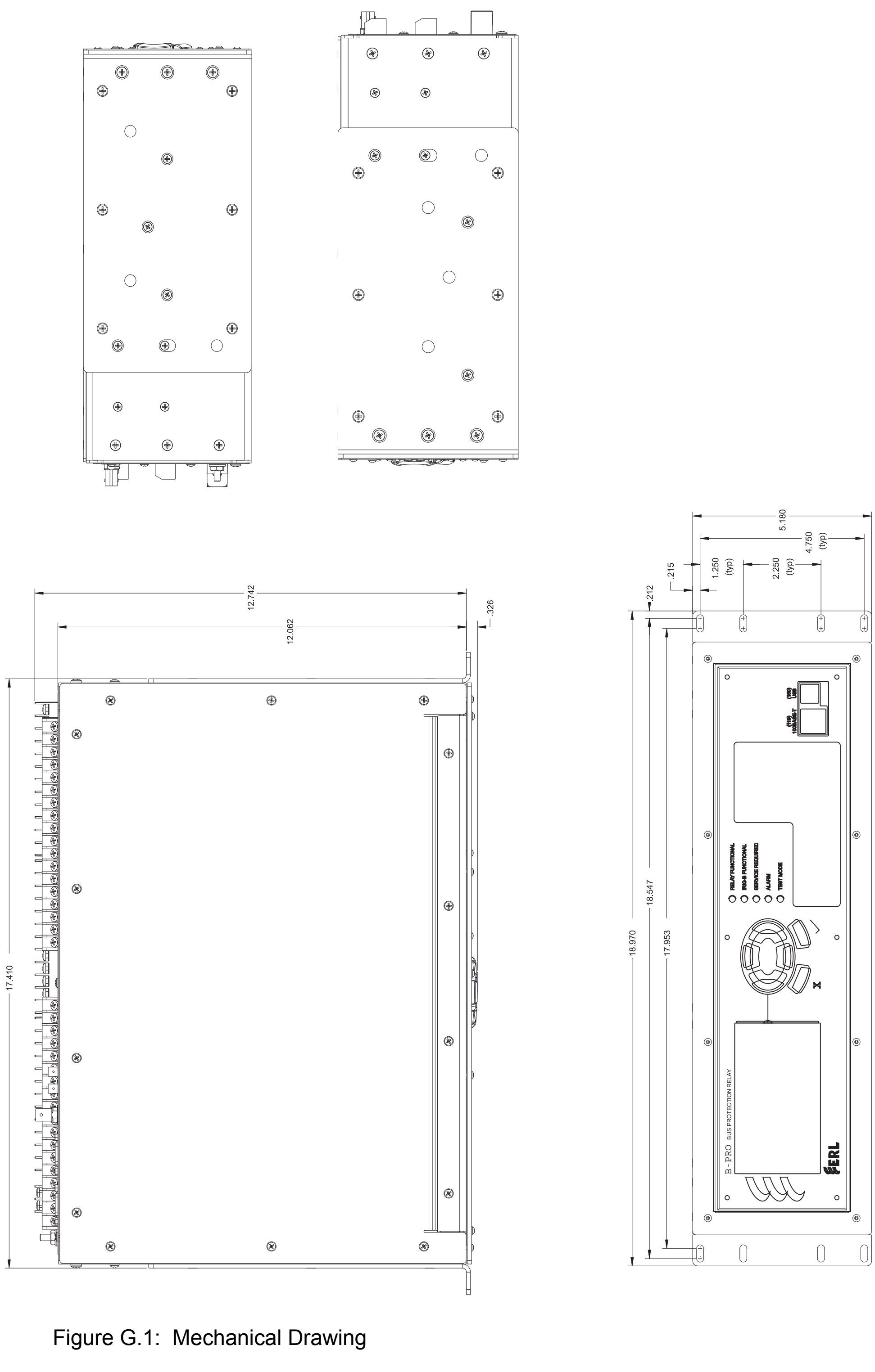



Figure G.1: Mechanical Drawing

# Appendix H Rear Panel Drawings

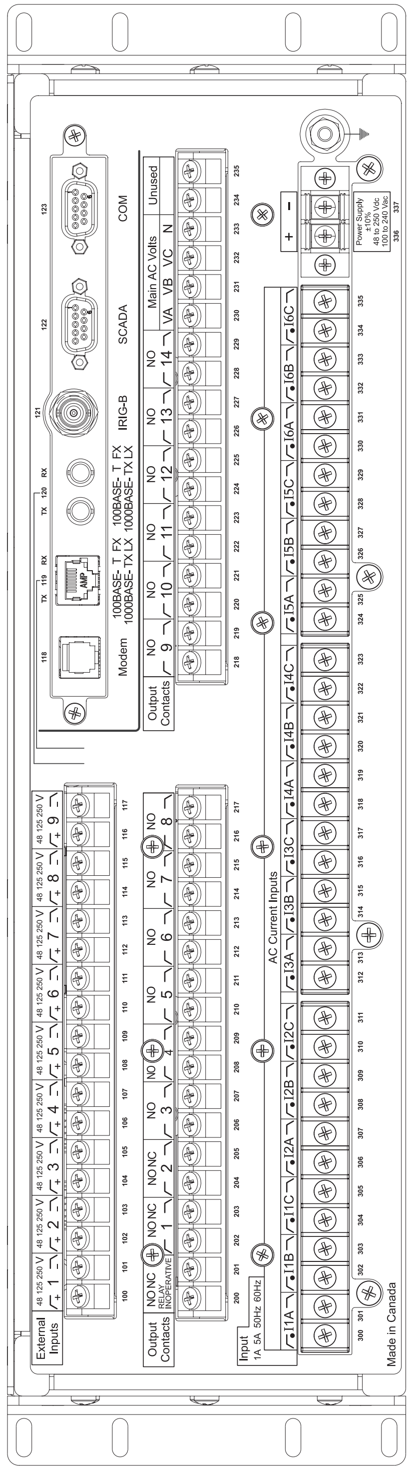



Figure H.1: Rear Panel

# Appendix I AC Schematic Drawing

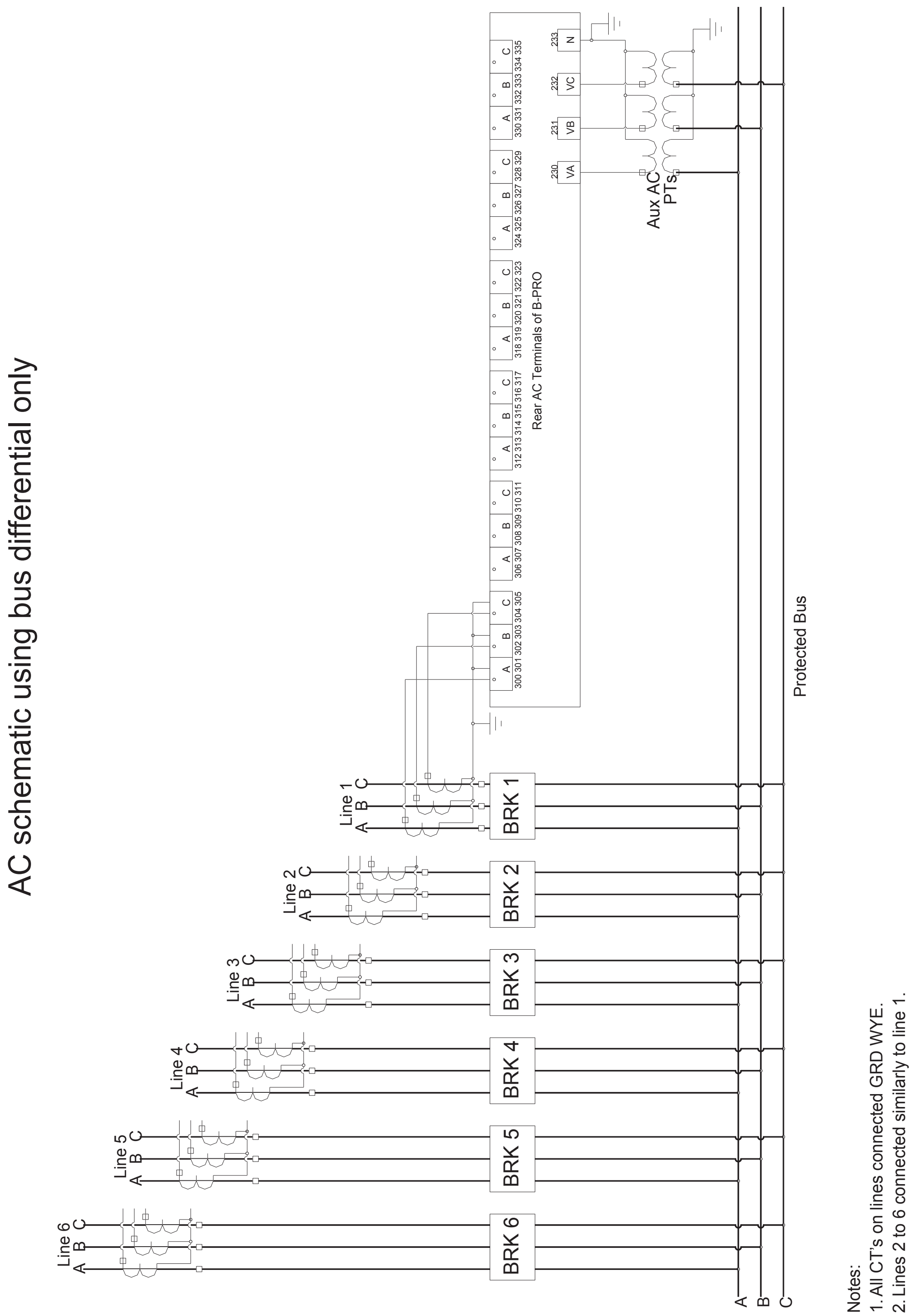



Figure I.1: AC Schematic (bus differential)

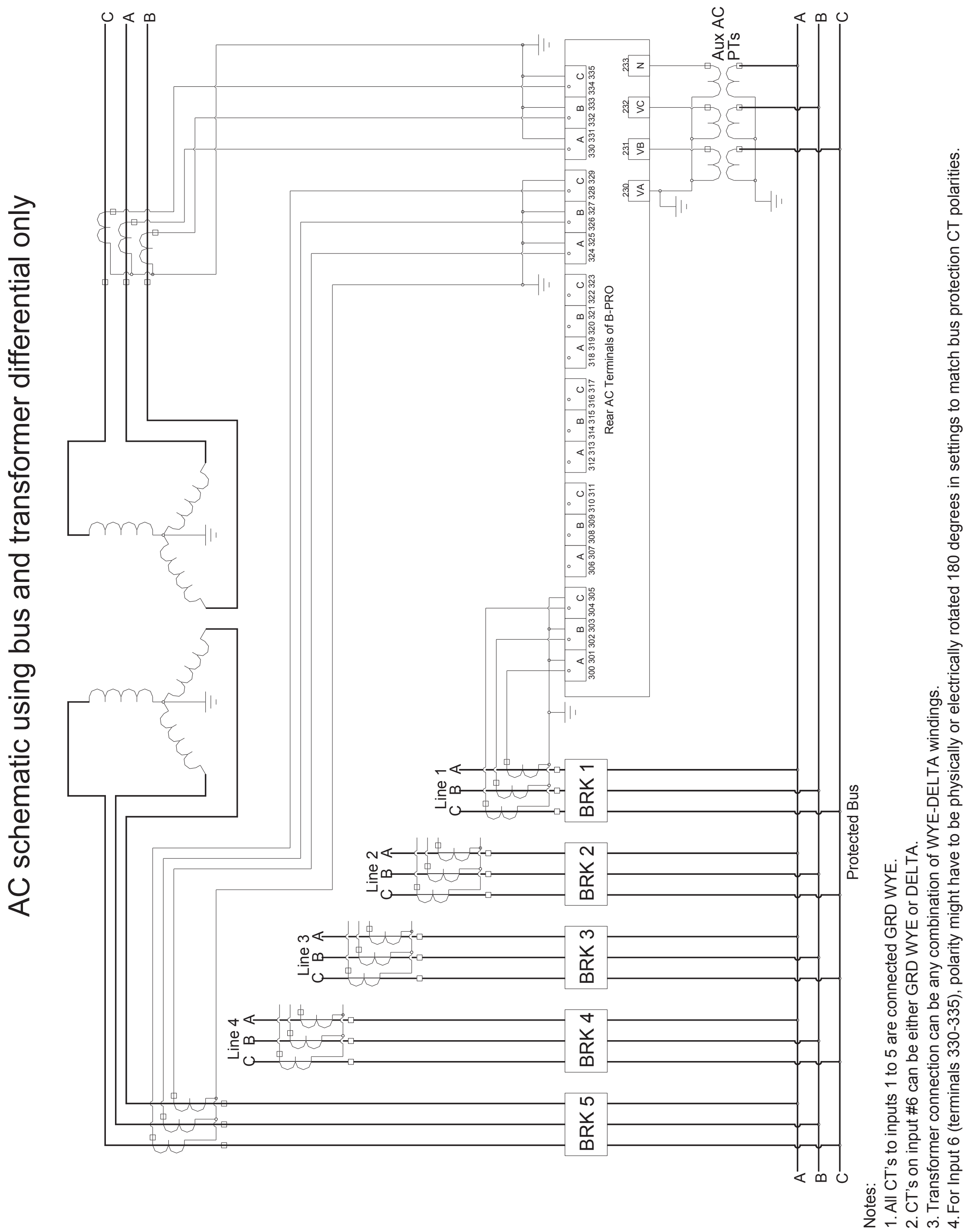
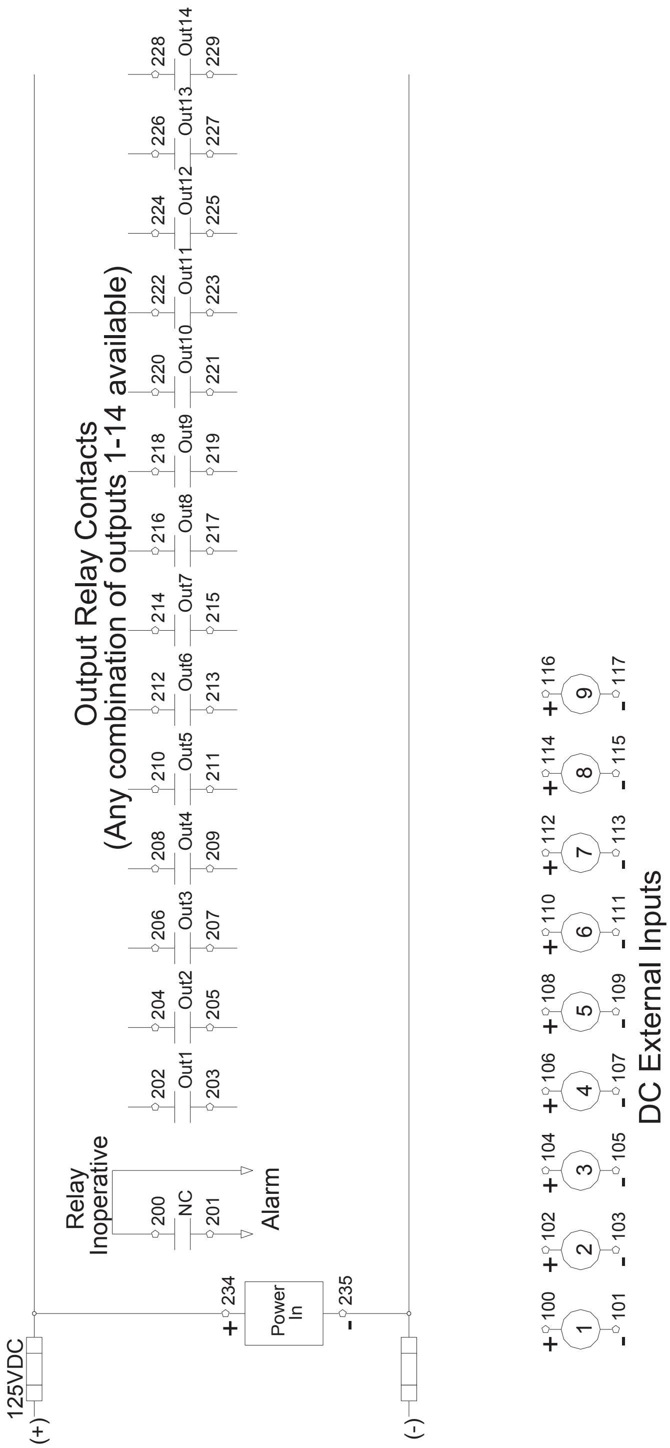



Figure I.2: AC Schematic (bus and transformer differential)

# Appendix J DC Schematic Drawing




Notes:
1. IRIG-B and comm ports shown separately on B-PRO rear panel layout drawing # 670003
2. All output relays are N.O. and can be programmed to operate on any relay function.
3. All outputs are rated tripping duty, interrupting via breaker aux "a" contact
4. DC External Inputs are available for 48/125/250VDC ranges.

Figure J.1: DC Schematic

# Appendix K Bus Differential Function Setting Examples

## Introduction

The B-PRO Bus Protection Relay provides low-impedance differential protection for transmission and distribution buses, for up to 6 three-phase inputs. The B-PRO is a per-unit based relay, meaning all secondary currents entering the relay are converted to per-unit values for protection calculations. Choosing the correct per-unit base for the current permits the development of standard protection settings that work for most bus protection applications. The resulting settings method only requires 2 calculations to implement.

The settings described in this technical note will provide a good balance between dependability and security of the protection system. This method also assumes the CTs have burdens within their ratings, and that the measured secondary current by the CTs is between 0.2 A and 15 A secondary.

## Bus Differential (87B-1 and 87B-2 Protection Function Characteristic

The operating characteristic of the 87B function is shown in Figure 1. IOmin is the minimum operating current for fault detection. IRs is the setting for the breakpoint between the region of slope S1 and the region of slope S2. IRs is normally used as the upper limit of the load range, or the protection zone used to detect bus faults during normal load conditions. The S2 region is therefore used for protection during through-fault events, where CT measurement errors can be quite large. The High Current Setting is an un-restrained differential element. Settings are described more completely in the B-PRO instruction manual.

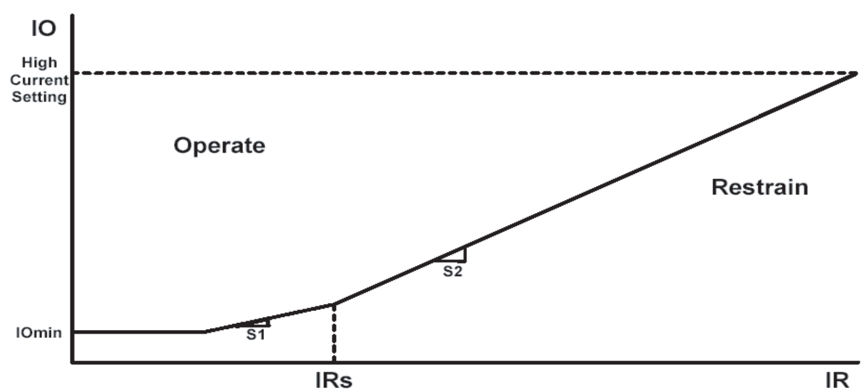



Figure K.1: 87B Operating Characteristic

In addition to this operating characteristic, the B-PRO includes a CT Saturation Detection algorithm that correctly identifies CT saturation due to external faults, and blocks the differential element from tripping.

While performing setting calculations for the B-PRO, the *IO* operate current is calculated by the equation:

$$IO = |I_1| + |I_2| + |I_3| + |I_4| + |I_5| + |I_6| A_{pu} \tag{1}$$

The restraint current *IR* calculation is:

$$IO = |\vec{I}_1 + \vec{I}_2 + \vec{I}_3 + \vec{I}_4 + \vec{I}_5 + \vec{I}_6| A_{pu} \tag{2}$$

## Settings Philosophy

The recommended settings method described in this technical note is simple: choose the MVA Base setting of the relay such that the maximum bus transfer load current is equal to the IRs setting in per-unit current. All other settings are related to the per-unit base current. The preferred setting for IRs is 2 per-unit, but there are some applications where a higher value is required. This method ensures that IRs is the upper limit setting for the load range, provides dependability for normal operating conditions, and provides adequate security for through-fault events.

The basic settings philosophy is to make sure operating and restraint current values (during normal operating conditions) fall in the load range. This means the S1 range accommodates the actual operating current, accounting for the maximum CT measurement error under any load condition. External fault conditions will be in the S2 or High Current range of the characteristic. Figure 2 describes recommended settings for most bus differential applications.

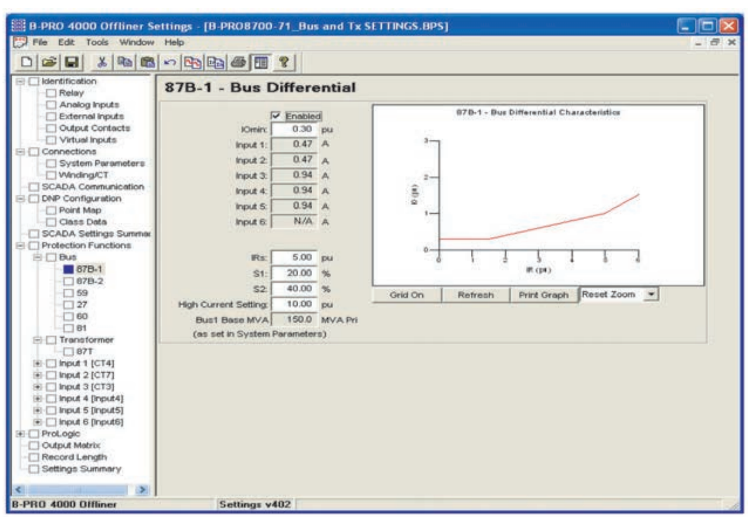



Figure K.2: 87B-1 settings

## Settings Method

The clearest way to understand the proposed bus differential settings method is through a specific example. Figure 3 illustrates normal load conditions.

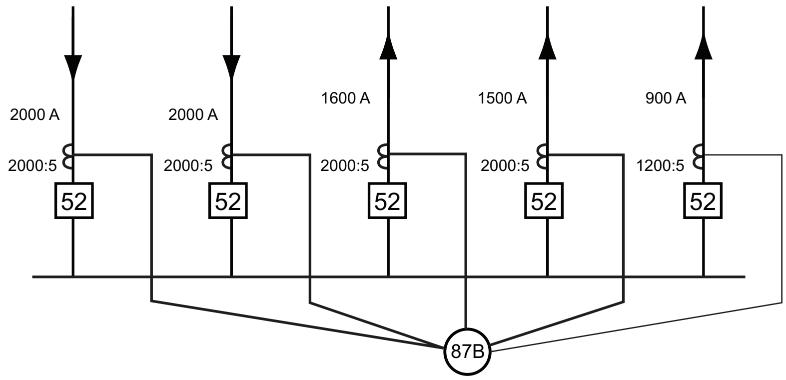



Figure K.3: Bus Transfer Load

Settings are developed using simple steps:

1. Enter Winding/CT connection information.
2. Determine the maximum bus transfer current.
3. Choose a value for IRs.
4. Calculate the Bus Base MVA.
5. Determine the CT Saturation Block Timer.
6. Enter settings in the B-PRO.

### 1. Enter Winding/CT Connection Information

Enter Winding and CT connection information to match the specific bus protection application as in the example of Figure K.4: Winding/CT Connections Settings on page 3.

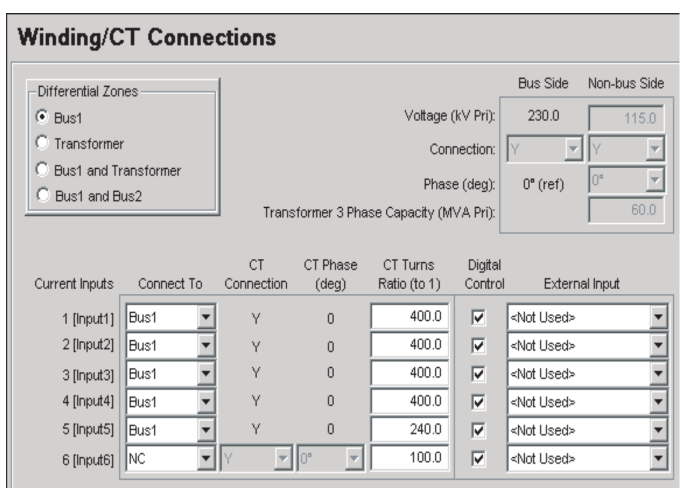



Figure K.4: Winding/CT Connections Settings

### 2. Determine the Maximum Bus Transfer Current

The maximum bus transfer current is going to be based on the CT primary ratings. For the example of Figure 3, there are many load flow configurations possible, but it is not possible to exceed an inflow of 4000 Apri without exceeding at least one CT rating. Therefore, 4000 Apri is the maximum bus transfer condition for this bus. It is possible, of course, for the maximum bus transfer current to be smaller than the rating limits of the CTs due to other system constraints.

### 3. Choose a Value for IRs

The IRs setting determines the break point between the slope S1 and slope S2. The IRs setting is also the upper limit of the load range of the B-PRO. For this recommended settings method, the maximum bus transfer current is equal to IRs in per-unit current. The preferred setting for IRs is 2 per-unit, which will work for most applications, but IRs can be any whole number 2 or greater. This method ensures the IR restraint current of the B-PRO for maximum bus transfer current is always within the upper limit of the load range.

### 4. Calculate the *Bus Base MVA*

The B-PRO does not have an explicit setting for the current base, but calculates the current base from the Bus Voltage and Bus Base MVA settings. Therefore, choosing the base current requires calculating the Bus Base MVA.

$$BusBaseMVA = \sqrt{3} \times BusVoltage \times BaseCurrent \tag{3}$$

$$Maximum\ Bus\ Transfer\ Current = IRS$$

$$BaseCurrent = \frac{MaximumBusTransferCurrent\langle A_{pri}\rangle}{IRs\langle A_{pu}\rangle}$$

For the configuration of Figure K.3: Bus Transfer Load on page 3 the maximum bus transfer current = 4000 A, and IRs = 2 pu.

$$BaseCurrent = \frac{4000A_{pri}}{2A_{pu}} = 2000A \tag{4}$$

$$BusBaseMVA = \sqrt{3} \times 138kV \times 2000A = 478MVA$$

Enter this amount as a relay setting in System Parameter as illustrated in Figure K.5: System Parameters settings on page 5.

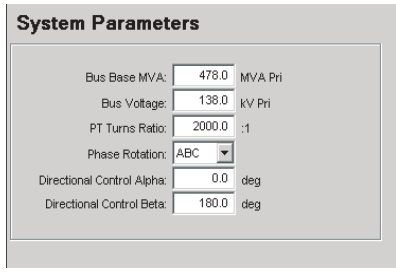



Figure K.5: System Parameters settings

The maximum relay setting for the Bus Base MVA in the B-PRO is 10000 MVA. If the calculated Bus Base MVA exceeds this value, choose the next higher whole number value for IRs (3 per-unit in this example), and re-calculate the Bus Base MVA.

### 5. Determine the CT Saturation Block Timer

The settings method used assumes the CT Saturation Detector is enabled. When an external fault occurs on a feeder, it can look like an internal fault if the feeder CTs saturate sufficiently. The "saturation detection algorithm" detects this condition and blocks tripping. It does not block tripping for CT saturation during an internal fault.

Once the CT Saturation Detector has identified a CT saturation condition, the 87B function is blocked from tripping until the CT Saturation Max Block timer expires. This setting should be greater than the slowest fault clearing time for any of the feeders connected to the bus. A typical clearing time is 5 cycles, or 2 cycles to recognize the fault and 3 cycles for the circuit breaker to open. The minimum setting of 0.10 seconds provides some safety margin.

### 6. Enter Settings in the B-PRO

The un-restrained differential High Current Setting should be set at 5 x IRs. For this example, 5 x 2 = 10 per-unit. IOmin is set at 0.25 per-unit, other than for applications with widely diverse CT ratios. S1 is recommended to be at 25%, and S2 at 50%, as shown in Figure 2.

To help determine whether any CT saturation will occur for any of the external fault conditions, use ERLPhase CT Saturation Program located on the CD provided with the relay.

### Widely Diverse CT Ratios

"Widely diverse CT ratios" differ by more than 5-to-1 (for example, 1200:5 and 8000:5). With widely diverse CT ratios, there is a possibility of false tripping under light load conditions. Consider a case such as Figure 6: Widely diverse CT ratios

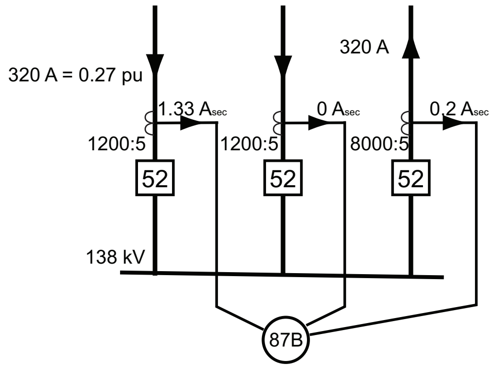



Figure K.6: Widely diverse CT ratios

Assume that the base current is chosen in the same way described by this Technical Note. Thus the *maximum bus transfer current* through this bus is 2400 A, and the *base current* for the bus differential protection is 2400 A/2 = 1200 A.

When the secondary current of a nominally 5A CT is as small as 0.2 A, there is a possibility that the current may be interpreted as close to zero amps due to CT error and A-to-D conversion error. Assuming the worst case, 0.2 amps is interpreted as zero amps by the relay.

Then, for this light load condition the operating current, IO, is perceived as

320 - 0 = 320 primary amps. On a 1200 A base this is 0.27 per-unit, which is above the recommended setting for IOmin, namely 0.25 per-unit. For this case, it is recommended to set IOmin to 0.4 per-unit in order to prevent possible false tripping of the bus.

# Appendix L Function Logic Diagram

Diagram in plastic sleeve.

# Appendix M Analog Phase Shift Table

| +30°(-330°) Shift | +60°(-300°) Shift |
|---|---|
| $IA = \frac{Ia - Ib}{\sqrt{3}}$ | $IA = \frac{Ia - 2Ib + Ic}{3}$ |
| $IB = \frac{Ib - Ic}{\sqrt{3}}$ | $IB = \frac{Ib - 2Ic + Ia}{3}$ |
| $IC = \frac{Ic - Ia}{\sqrt{3}}$ | $IC = \frac{Ic - 2Ia + Ib}{3}$ |

| +90°(-270°) Shift | +120°(-240°) Shift |
|---|---|
| $IA = \frac{Ic - Ib}{\sqrt{3}}$ | $IA = \frac{2Ic - Ia - Ib}{3}$ |
| $IB = \frac{Ia - Ic}{\sqrt{3}}$ | $IB = \frac{2Ia - Ib - Ic}{3}$ |
| $IC = \frac{Ib - Ia}{\sqrt{3}}$ | $IC = \frac{2Ib - Ic - Ia}{3}$ |

| +150°(-210°) Shift | -30°(+330°) Shift |
|---|---|
| $IA = \frac{Ic - Ia}{\sqrt{3}}$ | $IA = \frac{Ia - Ic}{\sqrt{3}}$ |
| $IB = \frac{Ia - Ib}{\sqrt{3}}$ | $IB = \frac{Ib - Ia}{\sqrt{3}}$ |
| $IC = \frac{Ib - Ic}{\sqrt{3}}$ | $IC = \frac{Ic - Ib}{\sqrt{3}}$ |

| -60°(+300°) Shift | -90°(+270°) Shift |
|---|---|
| $IA = \frac{Ia - 2Ic + Ib}{3}$ | $IA = \frac{Ib - Ic}{\sqrt{3}}$ |
| $IB = \frac{Ib - 2Ia + Ic}{3}$ | $IB = \frac{Ic - Ia}{\sqrt{3}}$ |
| $IC = \frac{Ic - 2Ib + Ia}{3}$ | $IC = \frac{Ia - Ib}{\sqrt{3}}$ |

| -120°(+240°) Shift | -150°(+210°) Shift |
|---|---|
| $IA = \frac{2Ib - Ic - Ia}{3}$ | $IA = \frac{Ib - Ia}{\sqrt{3}}$ |
| $IB = \frac{2Ic - Ia - Ib}{3}$ | $IB = \frac{Ic - Ib}{\sqrt{3}}$ |
| $IC = \frac{2Ia - Ib - Ic}{3}$ | $IC = \frac{Ia - Ic}{\sqrt{3}}$ |

| 0° Shift | ±180° Shift |
|---|---|
| $IA = \frac{2Ia - Ib - Ic}{3}$ | $IA = \frac{Ic - 2Ia + Ib}{3}$ |
| $IB = \frac{2Ib - Ic - Ia}{3}$ | $IB = \frac{Ia - 2Ib + Ic}{3}$ |
| $IC = \frac{2Ic - Ia - Ib}{3}$ | $IC = \frac{Ib - 2Ic + Ia}{3}$ |

# Appendix N How to Start the CT Saturation Calculator

The CT Saturation Calculator will assist the user with setting the B-PRO relay. This program is a Microsoft Excel spreadsheet. It is available from the downloads page on ERLPhase's Website (http://www.erlphase.com/customer_care.php). The CT Saturation Calculator tool is also included on the B-PRO software CD.

#### Run from the CD

7. Insert the B-PRO CD into the CD-ROM drive.
8. If the CD does not open automatically, browse the CD and locate the ERLPhase.exe file in the root of the CD. Double-click on the file to run it.
9. Select either the text *B-PRO Bus Protectio*n, located below the image of the relay, or the B-PRO text in the upper right hand corner of the start page.
10. Select the text *Install CT Saturation Software*. This will launch Microsoft Excel either directly or from within the default web browser. Refer to the instructions at the top of the spreadsheet for further descriptions.

#### Copy to the hard drive

1. Use Windows File Manager to copy *CT_Sat.xls* from the B-PRO CD to a directory on the local hard drive.
2. When the user needs to access the program either double-click on the file or launch Microsoft Excel and use the standard *File Open* menu items to start the spreadsheet. The user can also create a short cut icon on the desktop to run the CT program for convenience.

# Appendix O Application Examples

## O.1 Example 1: B-PRO Bus Differential Protection Settings

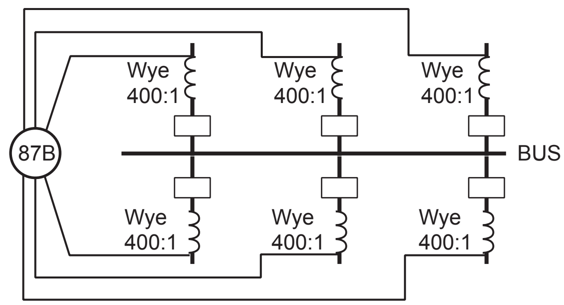



Figure O.1: Bus Differential Protection Example

Let's apply a B-PRO bus differential relay to the bus shown.

### Operating Principle

The B-PRO bus protection relay is a low impedance type of differential protection (87B) that is suitable for the protection of ac bus configurations at all voltages.

The differential protection operates with existing line CTs. The differential equation is based on a minimum plus two slope characteristic in the current restraint and operating regions. This characteristic adds security to the B-PRO relay even if some CT saturation is present.

**I Operate**

(IO) = vector sum of all line per unit currents on a phase by phase basis.

**I Restraint**

(IR) = absolute sum of all line per unit currents divided by 2.

To relate all the line currents to their actual currents, IR and IO are shown in per unit quantities. A base MVA quantity must be entered in the B-PRO setting process.

If required, B-PRO also allows a separate differential zone around an adjacent transformer (87T) to be defined. B-PRO's differential transformer protection is established from Input 5 and Input 6. Input 5 is common to both the transformer and the bus differential protection.

## Presetting Overview

To successfully set and apply the B-PRO bus differential relay, preliminary checks need to be done to determine relay stability for external faults.

Here are the steps needed:

1. Determine the maximum fault current at the bus with the contributions from each of the connected lines. Check to see if any of the line CTs saturate for a bus fault. Determine the worst case for this. e.g. (three phase or single line to ground) with a fully offset waveform.
2. Determine the maximum fault current possible of each line for a fault just outside each of the line CTs.
3. Determine if any saturation occurs for any line fault. Use our CT Saturation calculator software to determine any CT saturation curves conditions, see. When the degree of any saturation is known, the bus differential relay setting can be determined.

The user should use the highest fault values specific to the fault type, for this example assume the maximum fault current is a symmetrical single line to ground fault with a magnitude of 20 kA, Bus Base MVA = 100 MVA, and Bus Voltage = 230 kV. With the maximum fault current equal to 20 kA symmetrical, the CTs must be capable of producing a fully offset waveform equivalent to 40 kA asymmetrical.

Most CTs are capable of producing 20 times their nominal rated current into a standard ohm burden with a specified error.

For instance a 10L800 (C800) rated CT can output 100 A secondary into an 8 ohm burden with a maximum error of 10%.

To set the CT ratio properly allowing for 20 times nominal secondary current, where I nominal = 5 A, and I primary = 40 kA we end up with:

I primary/ I nominal * 20 = 40000/5 * 20 = 400:1 CT ratio.

| Line | Bus Fault | Bus Fault Per Unit | Bus Fault Secondary | External Line Fault | Line Fault Per Unit | Line Fault Secondary |
|---|---|---|---|---|---|---|
| Line 1 | **3 kA** | **12.0 pu** | **7.5 amps** | **17 kA** | **68.0 pu** | **42.5 amps** |
| Line 2 | **3** | **12.0** | **7.5** | **17** | **68.0** | **42.5** |
| Line 3 | **5** | **20.0** | **12.5** | **15** | **60.0** | **37.5** |
| Line 4 | **2** | **8.0** | **5.0** | **18** | **72.0** | **45.0** |
| Line 5 | **7** | **28.0** | **17.5** | **13** | **52.0** | **32.5** |
| Line 6 | **0** | **0.0** | **0.0** | **20** | **80.0** | **50.0** |

Note: CT ratio for all lines is 400:1. The CT ratio can be different, but must be all wye connected.

4. Determining the maximum fault currents for a bus fault from the above table shows the maximum faults from 0.0 to 3.5 times nominal secondary current (0.0-17.5A).
5. Determining the fault currents for a line fault just outside the line CTs from the above table shows the maximum faults from 6.5 to 10.0 times nominal secondary current (32.5-50.0A).
6. The next step is to determine whether any CT saturation will occur for any of the external line fault conditions. The user can use the ERLPhase CT Saturation program, or any other method to determine the CT response. The ERLPhase CT Saturation program was used to determine Line 6 CT (which will be exposed to the highest fault levels) response for 0% offset and 100% offset.

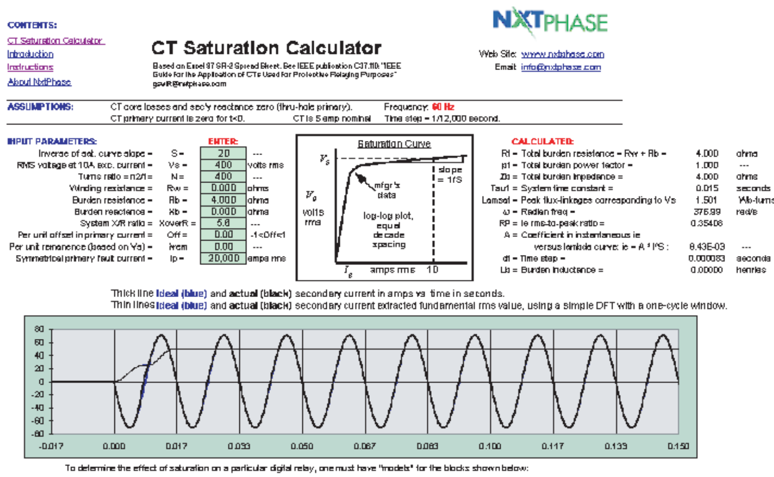



Figure O.2: 0% Offset

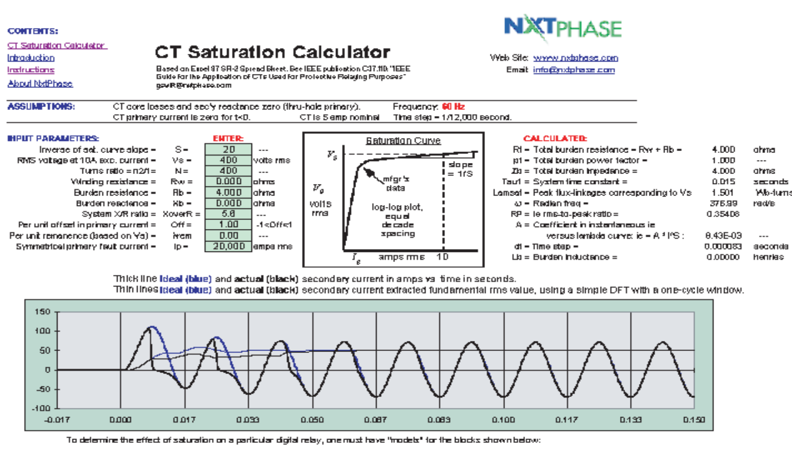



Figure O.3: 100% Offset

The ERLPhase CT Saturation program plots the ideal and actual CT response curve. The first plot shows the CT response and the second plot shows the phase angle error. With the 20 kA fault level, the assumptions made about the

burden and the system X/R ratio, we can determine that the Line 6 CT will have some error in it's secondary current. The heavy lines on the first plot indicate the ideal versus the actual response of the CT. The light lines on the first plot indicate the ideal fundamental component with ideal response versus the actual fundamental component with CT response as indicated.

The CT response near the 0.033 ms time period shows the fundamental response to be 80% of the ideal value (0.8). The CT phase angle error near the 0.033 time period shows the phase error to be about 20 degrees. (Phase error information is available in the calculation listing below the plot.)

We can establish the performance of Line 6 CT as 0.8 x 80 per unit = 64 per unit with a 20 degree phase angle error. The effective IO of Line 6 CT can now be established as 0.8 x 80 per unit x Cosine 20 degrees = 60 per unit. For the Line 6 external fault we can see that CT is not producing enough IO to compensate for the remaining line CTs. The effective IO can be established as IOcombined - IOline 6. Therefore 80 - 60 = 20 per unit IO. The effective IR can be established as IOcombined /2 + IOline 6 /2. Therefore 80/2 + 60/2 = 70 per unit IR.

Therefore IR = 70 per unit, and IO = 20 per unit for an external fault on Line 6. Continuing with this example we will show how to determine the IOmin, IRs, S1, S2, and High Current Settings for the 87B differential function.

## Setting the 87B Function

### IOmin

After the values of IO and IR have been determined for the application, the device 87B can be set. The IOmin setting determines the maximum sensitivity of the bus differential relay under light load conditions. If a 100 A minimum bus fault level is desired, we would set IOmin to 0.40 per unit (100/250). I per unit = MVA base / (1.73 * Vbase) = 100 MVA /(1.73 x 230 kV).

### IRs

As the bus load increases IR increases. For the case where lines 1 through 6 become loaded to 5 A secondary, the bus load would be 2000 A primary on each line. The IRcombined becomes (2000x6) / (2 x 250) = 24 per unit, we would set IRs to 24.00.

### S1

For the case where lines 1 through 6 become loaded to 5 A secondary, with a 10% CT error we set IOcombined x 10% = 48 per unit x 10% = 4.8 or about 5 per unit. With IO = 5 per unit and IR = 24 per unit setting S1 =22.00, this criterion is met.

### S2

When entering the bus fault region, IR and IO become larger. The calculations from step 3 determined the IR = 72 per unit and IO = 60 per unit. To add some security we will assume a 10% error in line CTs 1 through 5 and then add a 25% margin to IO. The IOcombined then becomes 88 per unit and the IRcombined becomes 44 per unit.

- The effective IO can be established as IOcombined - IOline 6 = 88 - 60 = 28 per unit.
- The effective IR can be established as IOcombined /2 + IOline 6 /2 = 88/2 + 60/2 = 74 per unit.

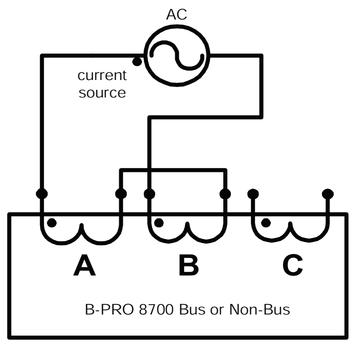
Therefore IR = 74 per unit, and IO = 28 per unit for an external fault on Line 6 with a 10% CT error on Lines 1 through 6. The user can add a 25% margin to the IO value for stability during through fault conditions.   With IO = 35 per unit and IR = 74 per unit setting S2 = 60.00, this criterion is met.

### High Current Setting

The final setting is for the unrestrained value. In this example we will set the value to operate for bus faults and provide stability for external faults. A setting of 2 times the maximum IO per unit value for the external line fault case on Line 6 is appropriate, setting High Current Setting = 56.00 per unit, this criterion is met.

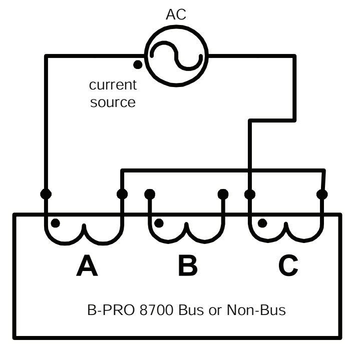
# Appendix P Connections

0° Connection



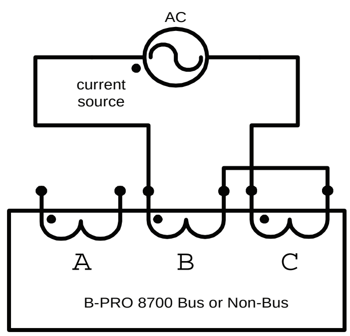

87T Single Phase Correction Factor = 1.0

+60° Connection



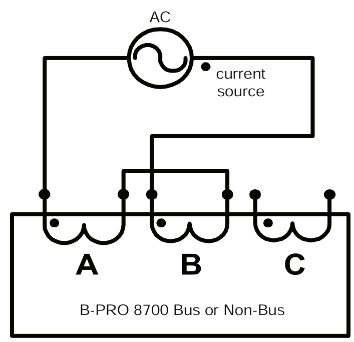

87T Single Phase Correction Factor = 1.0

+120 Connection



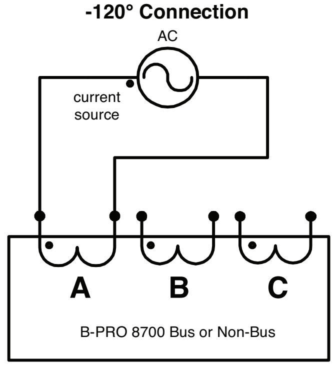

87T Single Phase Correction Factor = 1.0

180° Connection



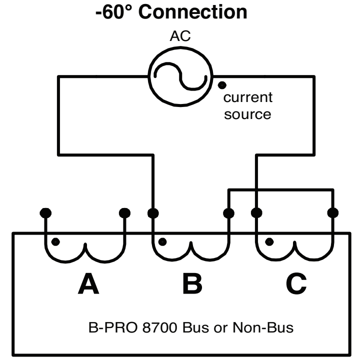

87T SinglePhase Correction Factor = 1.0

-120° Connection



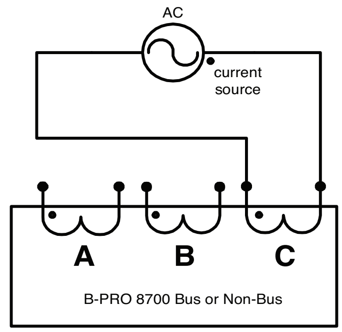

87T Single Phase Correction Factor = 1.0

-60° Connection



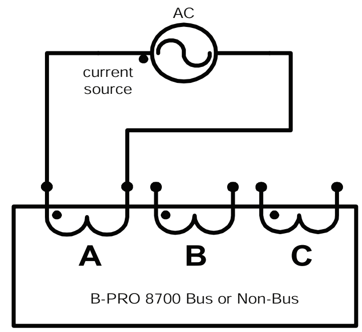

87T Single Phase Correction Factor = 1.0

**+30° Connection**



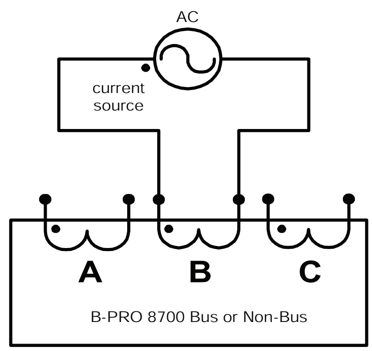

87T Single Phase Correction Factor = 3

**+90˚ Connection**



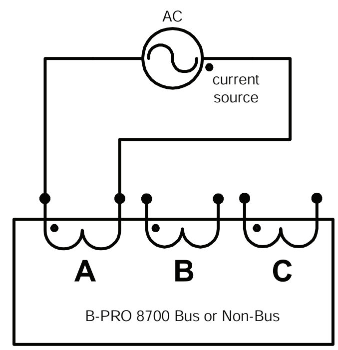

87T Single Phase Correction Factor = √3

**+150˚ Connection**



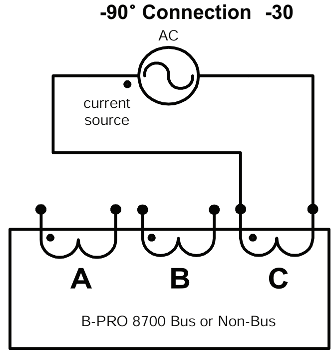

87T Single Phase Correction Factor = √3

**-150˚ Connection**



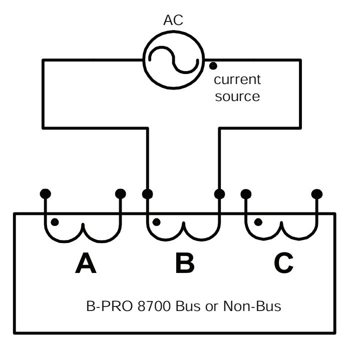

87T Single Phase Correction Factor = √3

**-90˚ Connection -30**




87T Single Phase Correction Factor = √3

**-30˚ Connection**




87T Single Phase Correction Factor = 3

# Appendix Q. IEC 61850 Implementation

## Q.1 Protocol Implementation Conformance Statement (PICS)

### Introduction

This specification is the Protocol Implementation Conformance Statement (PICS) and presents the ACSI conformance statements as defined in Annex A of Part 7-2 of the IEC 61850 standard specifications.

#### ACSI basic conformance statement

The basic conformance statement shall be as defined in Table N.1: Basic Conformance Statement.

### Specifications

#### B-PRO logical devices

B-PRO logical device identifications

B-PRO 4000 has the following IEC 61850 logical devices defined in its ICD file:

- BPROMeasurements
- BPROProtection
- BPROSystem
- BPROVirtualElements

#### B-PRO logical nodes

"B-PRO Logical Devices" in Appendix Q.defines the list of logical nodes (LN) for the B-PRO logical devices.

Note: System logical nodes (group L) are not shown here.

**Table Q.11: B-PRO Logical Devices**

| LD Name | LN Name | LN Description | B-PRO Protection Function | Comments | Section |
|---|---|---|---|---|---|
| LD Name | LN Name | LN Description | B-PRO Protection Function | Comments | Section |
| BPROMeasurements | MMXU1 | Measurement | Metering Data | 3 phase measurement information for voltage input and current channel 1 | |
| BPROMeasurements | MMXU2 | Measurement | Metering Data | 3 phase measurement information for current channel 2 | |

| Table Q.11: B-PRO Logical Devices | | | | | |
|---|---|---|---|---|---|
| **LD Name** | **LN Name** | **LN Description** | **B-PRO Protection Function** | **Comments** | **Section** |
| BPROMeasurements | MMXU3 | Measurement | Metering Data | 3 phase measurement information for current channel 3 | |
| BPROMeasurements | MMXU4 | Measurement | Metering Data | 3 phase measurement information for current channel 4 | |
| BPROMeasurements | MMXU5 | Measurement | Metering Data | 3 phase measurement information for current channel 5 | |
| BPROMeasurements | MMXU6 | Measurement | Metering Data | 3 phase measurement information for current channel 6 | |
| BPROMeasurements | MSQI1 | Measurement | Metering Data | Positive, negative, and zero sequence currents for current channel 1 | |
| BPROMeasurements | MSQI2 | Measurement | Metering Data | Positive, negative, and zero sequence currents for current channel 2 | |
| BPROMeasurements | MSQI3 | Measurement | Metering Data | Positive, negative, and zero sequence currents for current channel 3 | |
| BPROMeasurements | MSQI4 | Measurement | Metering Data | Positive, negative, and zero sequence currents for current channel 4 | |
| BPROMeasurements | MSQI5 | Measurement | Metering Data | Positive, negative, and zero sequence currents for current channel 5 | |
| BPROMeasurements | MSQI6 | Measurement | Metering Data | Positive, negative, and zero sequence currents for current channel 6 | |
| BPROProtection | PDIF1 | Differential | Dev 87B-1 | Bus Differential Zone 1 phase | |
| BPROProtection | PDIF2 | Differential | Dev 87B-2 | Bus Differential Zone 2 phase | |
| BPROProtection | PDIF3 | Differential | Dev 87T | Transformer Differential phase | |
| BPROProtection | PTOV1 | Overvoltage | Dev 59-1 | Overvoltage 1 phase | |
| BPROProtection | PTOV2 | Overvoltage | Dev 59-2 | Overvoltage 2 phase | |
| BPROProtection | PTUV1 | Undervoltage | Dev 27-1 | Undervoltage 1 phase | |
| BPROProtection | PTUV2 | Undervoltage | Dev 27-2 | Undervoltage 2 phase | |
| | RVTS | TBD (not defined in standard and not in ICD file) | Dev 60 | Loss of Potential | |
| BPROProtection | PTUF1 | Underfrequency | Dev 81 U/F-1 | Underfrequency 1 | |

| Table Q.11: B-PRO Logical Devices | | | | | |
|---|---|---|---|---|---|
| **LD Name** | **LN Name** | **LN Description** | **B-PRO Protection Function** | **Comments** | **Section** |
| BPROProtection | PTUF2 | Underfrequency | Dev 81 U/F-2 | Underfrequency 2 | |
| BPROProtection | PTOF1 | Overfrequency | Dev 81 O/F-1 | Overfrequency 1 | |
| BPROProtection | PTOF2 | Overfrequency | Dev 81 O/F-2 | Overfrequency 2 | |
| BPROProtection | PIOC1 | Instantaneous Over-current | Input 1: Dev 50LS-1 | Low set overcurrent 1 phase | |
| BPROProtection | PIOC2 | Instantaneous Over-current | Input 2: Dev 50LS-1 | Low set overcurrent 1 phase | |
| BPROProtection | PIOC3 | Instantaneous Over-current | Input 3: Dev 50LS-1 | Low set overcurrent 1 phase | |
| BPROProtection | PIOC4 | Instantaneous Over-current | Input 4: Dev 50LS-1 | Low set overcurrent 1 phase | |
| BPROProtection | PIOC5 | Instantaneous Over-current | Input 5: Dev 50LS-1 | Low set overcurrent 1 phase | |
| BPROProtection | PIOC6 | Instantaneous Over-current | Input 6: Dev 50LS-1 | Low set overcurrent 1 phase | |
| BPROProtection | PIOC7 | Instantaneous Over-current | Input 1: Dev 50LS-2 | Low set overcurrent 2 phase | |
| BPROProtection | PIOC8 | Instantaneous Over-current | Input 2: Dev 50LS-2 | Low set overcurrent 2 phase | |
| BPROProtection | PIOC9 | Instantaneous Over-current | Input 3: Dev 50LS-2 | Low set overcurrent 2 phase | |
| BPROProtection | PIOC10 | Instantaneous Over-current | Input 4: Dev 50LS-2 | Low set overcurrent 2 phase | |
| BPROProtection | PIOC11 | Instantaneous Over-current | Input 5: Dev 50LS-2 | Low set overcurrent 2 phase | |
| BPROProtection | PIOC12 | Instantaneous Over-current | Input 6: Dev 50LS-2 | Low set overcurrent 2 phase | |
| BPROProtection | PIOC13 | Instantaneous over-current | Input 1: Dev 50/67 | Phase overcurrent phase | |
| BPROProtection | PIOC14 | Instantaneous over-current | Input 2: Dev 50/67 | Phase overcurrent phase | |
| BPROProtection | PIOC15 | Instantaneous over-current | Input 3: Dev 50/67 | Phase overcurrent phase | |
| BPROProtection | PIOC16 | Instantaneous over-current | Input 4: Dev 50/67 | Phase overcurrent phase | |
| BPROProtection | PIOC17 | Instantaneous over-current | Input 5: Dev 50/67 | Phase overcurrent phase | |
| BPROProtection | PIOC18 | Instantaneous over-current | Input 6: Dev 50/67 | Neutral overcurrent phase | |
| BPROProtection | PIOC19 | Instantaneous over-current | Input 1: Dev 50N/67 | Neutral overcurrent phase | |

| Table Q.11: B-PRO Logical Devices | | | | | |
|---|---|---|---|---|---|
| **LD Name** | **LN Name** | **LN Description** | **B-PRO Protection Function** | **Comments** | **Section** |
| BPROProtection | PIOC20 | Instantaneous over-current | Input 2: Dev 50N/67 | Neutral overcurrent phase | |
| BPROProtection | PIOC21 | Instantaneous over-current | Input 3: Dev 50N/67 | Neutral overcurrent phase | |
| BPROProtection | PIOC22 | Instantaneous over-current | Input 4: Dev 50N/67 | Neutral overcurrent phase | |
| BPROProtection | PIOC23 | Instantaneous over-current | Input 5: Dev 50N/67 | Neutral overcurrent phase | |
| BPROProtection | PIOC24 | Instantaneous over-current | Input 6: Dev 50N/67 | Neutral overcurrent phase | |
| BPROProtection | PIOC25 | Instantaneous over-current | Input 1: Dev 46-50/67 | Negative sequence over-current phase | |
| BPROProtection | PIOC26 | Instantaneous over-current | Input 2: Dev 46-50/67 | Negative sequence over-current phase | |
| BPROProtection | PIOC27 | Instantaneous over-current | Input 3: Dev 46-50/67 | Negative sequence over-current phase | |
| BPROProtection | PIOC28 | Instantaneous over-current | Input 4: Dev 46-50/67 | Negative sequence over-current phase | |
| BPROProtection | PIOC29 | Instantaneous over-current | Input 5: Dev 46-50/67 | Negative sequence over-current phase | |
| BPROProtection | PIOC30 | Instantaneous over-current | Input 6: Dev 46-50/67 | Negative sequence over-current phase | |
| BPROProtection | PTOC1 | Time overcurrent | Input 1: Dev 51/67 | Phase overcurrent phase | |
| BPROProtection | PTOC2 | Time overcurrent | Input 2: Dev 51/67 | Phase overcurrent phase | |
| BPROProtection | PTOC3 | Time overcurrent | Input 3: Dev 51/67 | Phase overcurrent phase | |
| BPROProtection | PTOC4 | Time overcurrent | Input 4: Dev 51/67 | Phase overcurrent phase | |
| BPROProtection | PTOC5 | Time overcurrent | Input 5: Dev 51/67 | Phase overcurrent phase | |
| BPROProtection | PTOC6 | Time overcurrent | Input 6: Dev 51/67 | Phase overcurrent phase | |
| BPROProtection | PTOC7 | Time overcurrent | Input 1: Dev 51N/67 | Neutral overcurrent phase | |
| BPROProtection | PTOC8 | Time overcurrent | Input 2: Dev 51N/67 | Neutral overcurrent phase | |
| BPROProtection | PTOC9 | Time overcurrent | Input 3: Dev 51N/67 | Neutral overcurrent phase | |
| BPROProtection | PTOC10 | Time overcurrent | Input 4: Dev 51N/67 | Neutral overcurrent phase | |
| BPROProtection | PTOC11 | Time overcurrent | Input 5: Dev 51N/67 | Neutral overcurrent phase | |
| BPROProtection | PTOC12 | Time overcurrent | Input 6: Dev 51N/67 | Neutral overcurrent phase | |
| BPROProtection | PTOC13 | Time overcurrent | Input 1: Dev 46-51/67 | Negative sequence over-current phase | |
| BPROProtection | PTOC14 | Time overcurrent | Input 2: Dev 46-51/67 | Negative sequence over-current phase | |

| Table Q.11: B-PRO Logical Devices | | | | | |
|---|---|---|---|---|---|
| **LD Name** | **LN Name** | **LN Description** | **B-PRO Protection Function** | **Comments** | **Section** |
| BPROProtection | PTOC15 | Time overcurrent | Input 3: Dev 46-51/67 | Negative sequence over-current phase | |
| BPROProtection | PTOC16 | Time overcurrent | Input 4: Dev 46-51/67 | Negative sequence over-current phase | |
| BPROProtection | PTOC17 | Time overcurrent | Input 5: Dev 46-51/67 | Negative sequence over-current phase | |
| BPROProtection | PTOC18 | Time overcurrent | Input 6: Dev 46-51/67 | Negative sequence over-current phase | |
| BPROProtection | RBRF1 | Breaker failure | Input 1: Dev 50BF-1 | Breaker failure | |
| BPROProtection | RBRF2 | Breaker failure | Input 2: Dev 50BF-1 | Breaker failure | |
| BPROProtection | RBRF3 | Breaker failure | Input 3: Dev 50BF-1 | Breaker failure | |
| BPROProtection | RBRF4 | Breaker failure | Input 4: Dev 50BF-1 | Breaker failure | |
| BPROProtection | RBRF5 | Breaker failure | Input 5: Dev 50BF-1 | Breaker failure | |
| BPROProtection | RBRF6 | Breaker failure | Input 6: Dev 50BF-1 | Breaker failure | |
| BPROProtection | RBRF7 | Breaker failure | Input 1: Dev 50BF-2 | Breaker failure | |
| BPROProtection | RBRF8 | Breaker failure | Input 2: Dev 50BF-2 | Breaker failure | |
| BPROProtection | RBRF9 | Breaker failure | Input 3: Dev 50BF-2 | Breaker failure | |
| BPROProtection | RBRF10 | Breaker failure | Input 4: Dev 50BF-2 | Breaker failure | |
| BPROProtection | RBRF11 | Breaker failure | Input 5: Dev 50BF-2 | Breaker failure | |
| BPROProtection | RBRF12 | Breaker failure | Input 6: Dev 50BF-2 | Breaker failure | |
| BPROSystem | GGIO1 | General Process I/O | External Input 1 – 64 | External input status (only 1 – 20 are currently used) | |
| BPROSystem | GGIO2 | General Process I/O | Output Contact 1-64 | Output contact status (only 1 – 21 are currently used) | |
| BPROSystem | GGIO3 | General Process I/O | ProLogic 1 – 64 | Protection logic status (only 1 – 15 are currently used) | |
| BPROVirtualElements | GGIO1 | General Process I/O | Virtual Inputs 1 – 64 | Virtual input status (only 1 – 30 are currently used) | |
| BPROVirtualElements | GGIO2 | General Process I/O | Virtual Inputs 1 – 64 | Virtual input incoming controls (only 1 – 30 are currently supported) | |
| BPROVirtualElements | GGIO3 | General Process I/O | Virtual Inputs 1 – 64 | Virtual input outgoing controls (currently not supported) | |

### Logical node specifications

The following sections provide detailed information on the B-PRO logical nodes of the B-PRO logical devices as defined in the previous section.

### MMXU1

This section defines logical node data for the logical node MMXU1 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MMXU1.MX.Hz.mag.f | Frequency |
| MMXU1.MX.PhV.phsA.cVal.mag.f | Voltage Phase A |
| MMXU1.MX.PhV.phsA.cVal.ang.f | Voltage Phase A |
| MMXU1.MX.PhV.phsB.cVal.mag.f | Voltage Phase B |
| MMXU1.MX.PhV.phsB.cVal.ang.f | Voltage Phase B |
| MMXU1.MX.PhV.phsC.cVal.mag.f | Voltage Phase C |
| MMXU1.MX.PhV.phsC.cVal.ang.f | Voltage Phase C |
| MMXU1.MX.A.phsA.cVal.mag.f | Input 1: Current Phase A |
| MMXU1.MX.A.phsA.cVal.ang.f | Input 1: Current Phase A |
| MMXU1.MX.A.phsB.cVal.mag.f | Input 1: Current Phase B |
| MMXU1.MX.A.phsB.cVal.ang.f | Input 1: Current Phase B |
| MMXU1.MX.A.phsC.cVal.mag.f | Input 1: Current Phase C |
| MMXU1.MX.A.phsC.cVal.ang.f | Input 1: Current Phase C |

### MMXU2

This section defines logical node data for the logical node MMXU2 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| **Data name** | **Description** |
|---|---|
| MMXU2.MX.A.phsA.cVal.mag.f | Input 2: Current Phase A |
| MMXU2.MX.A.phsA.cVal.ang.f | Input 2: Current Phase A |
| MMXU2.MX.A.phsB.cVal.mag.f | Input 2: Current Phase B |
| MMXU2.MX.A.phsB.cVal.ang.f | Input 2: Current Phase B |
| MMXU2.MX.A.phsC.cVal.mag.f | Input 2: Current Phase C |
| MMXU2.MX.A.phsC.cVal.ang.f | Input 2: Current Phase C |

### MMXU3

This section defines logical node data for the logical node MMXU3 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MMXU3.MX.A.phsA.cVal.mag.f | Input 3: Current Phase A |
| MMXU3.MX.A.phsA.cVal.ang.f | Input 3: Current Phase A |
| MMXU3.MX.A.phsB.cVal.mag.f | Input 3: Current Phase B |
| MMXU3.MX.A.phsB.cVal.ang.f | Input 3: Current Phase B |
| MMXU3.MX.A.phsC.cVal.mag.f | Input 3: Current Phase C |
| MMXU3.MX.A.phsC.cVal.ang.f | Input 3: Current Phase C |

**MMXU4**

This section defines logical node data for the logical node MMXU4 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MMXU4.MX.A.phsA.cVal.mag.f | Input 4: Current Phase A |
| MMXU4.MX.A.phsA.cVal.ang.f | Input 4: Current Phase A |
| MMXU4.MX.A.phsB.cVal.mag.f | Input 4: Current Phase B |
| MMXU4.MX.A.phsB.cVal.ang.f | Input 4: Current Phase B |
| MMXU4.MX.A.phsC.cVal.mag.f | Input 4: Current Phase C |
| MMXU4.MX.A.phsC.cVal.ang.f | Input 4: Current Phase C |

**MMXU5**

This section defines logical node data for the logical node MMXU5 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MMXU5.MX.A.phsA.cVal.mag.f | Input 5: Current Phase A |
| MMXU5.MX.A.phsA.cVal.ang.f | Input 5: Current Phase A |
| MMXU5.MX.A.phsB.cVal.mag.f | Input 5: Current Phase B |
| MMXU5.MX.A.phsB.cVal.ang.f | Input 5: Current Phase B |
| MMXU5.MX.A.phsC.cVal.mag.f | Input 5: Current Phase C |
| MMXU5.MX.A.phsC.cVal.ang.f | Input 5: Current Phase C |

### MMXU6

This section defines logical node data for the logical node MMXU6 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MMXU6.MX.A.phsA.cVal.mag.f | Input 6: Current Phase A |
| MMXU6.MX.A.phsA.cVal.ang.f | Input 6: Current Phase A |
| MMXU6.MX.A.phsB.cVal.mag.f | Input 6: Current Phase B |
| MMXU6.MX.A.phsB.cVal.ang.f | Input 6: Current Phase B |
| MMXU6.MX.A.phsC.cVal.mag.f | Input 6: Current Phase C |
| MMXU6.MX.A.phsC.cVal.ang.f | Input 6: Current Phase C |

### MSQI1

This section defines logical node data for the logical node MSQI1 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MSQI1.MX.SeqA.c1.cVal.mag.f | Input 1: Positive Sequence Current |
| MSQI1.MX.SeqA.c2.cVal.mag.f | Input 1: Negative Sequence Current |
| MSQI1.MX.SeqA.c3.cVal.mag.f | Input 1: Zero Sequence Current |

### MSQI2

This section defines logical node data for the logical node MSQI2 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MSQI2.MX.SeqA.c1.cVal.mag.f | Input 2: Positive Sequence Current |
| MSQI2.MX.SeqA.c2.cVal.mag.f | Input 2: Negative Sequence Current |
| MSQI2.MX.SeqA.c3.cVal.mag.f | Input 2: Zero Sequence Current |

### MSQI3

This section defines logical node data for the logical node MSQI3 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MSQI3.MX.SeqA.c1.cVal.mag.f | Input 3: Positive Sequence Current |
| MSQI3.MX.SeqA.c2.cVal.mag.f | Input 3: Negative Sequence Current |
| MSQI3.MX.SeqA.c3.cVal.mag.f | Input 3: Zero Sequence Current |

### MSQI4

This section defines logical node data for the logical node MSQI4 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MSQI4.MX.SeqA.c1.cVal.mag.f | Input 4: Positive Sequence Current |
| MSQI4.MX.SeqA.c2.cVal.mag.f | Input 4: Negative Sequence Current |
| MSQI4.MX.SeqA.c3.cVal.mag.f | Input 4: Zero Sequence Current |

### MSQI5

This section defines logical node data for the logical node MSQI5 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MSQI5.MX.SeqA.c1.cVal.mag.f | Input 5: Positive Sequence Current |
| MSQI5.MX.SeqA.c2.cVal.mag.f | Input 5: Negative Sequence Current |
| MSQI5.MX.SeqA.c3.cVal.mag.f | Input 5: Zero Sequence Current |

### MSQI6

This section defines logical node data for the logical node MSQI6 of the BPROMeasurements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| MSQI6.MX.SeqA.c1.cVal.mag.f | Input 6: Positive Sequence Current |
| MSQI6.MX.SeqA.c2.cVal.mag.f | Input 6: Negative Sequence Current |
| MSQI6.MX.SeqA.c3.cVal.mag.f | Input 6: Zero Sequence Current |

### PDIF1

This section defines logical node data for the logical node PDIF1 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PDIF1.ST.Op.general | Operate (87B-1 Trip) |
| PDIF1.ST.Op.phsA | Operate (87B-1 Trip) Phase A |
| PDIF1.ST.Op.phsB | Operate (87B-1 Trip) Phase B |
| PDIF1.ST.Op.phsC | Operate (87B-1 Trip) Phase C |

### PDIF2

This section defines logical node data for the logical node PDIF2 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PDIF2.ST.Op.general | Operate (87B-2 Trip) |
| PDIF2.ST.Op.phsA | Operate (87B-2 Trip) Phase A |
| PDIF2.ST.Op.phsB | Operate (87B-2 Trip) Phase B |
| PDIF2.ST.Op.phsC | Operate (87B-2 Trip) Phase C |

### PDIF3

This section defines logical node data for the logical node PDIF3 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PDIF3.ST.Op.general | Operate (87T Trip) |
| PDIF3.ST.Op.phsA | Operate (87T Trip) Phase A |
| PDIF3.ST.Op.phsB | Operate (87T Trip) Phase B |
| PDIF3.ST.Op.phsC | Operate (87T Trip) Phase C |

### PTOV1

This section defines logical node data for the logical node PTOV1 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOV1.ST.Str.general | Start (59-1 Trip) |
| PTOV1.ST.Str.dirGeneral | Start (59-1 Trip) |
| PTOV1.ST.Str.phsA | Start (59-1 Trip) Phase A |
| PTOV1.ST.Str.dirPhsA | Start (59-1 Trip) Phase A |
| PTOV1.ST.Str.phsB | Start (59-1 Trip) Phase B |
| PTOV1.ST.Str.dirPhsB | Start (59-1 Trip) Phase B |
| PTOV1.ST.Str.phsC | Start (59-1 Trip) Phase C |
| PTOV1.ST.Str.dirPhsC | Start (59-1 Trip) Phase C |

### PTOV2

This section defines logical node data for the logical node PTOV2 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOV2.ST.Str.general | Start (59-2 Trip) |
| PTOV2.ST.Str.dirGeneral | Start (59-2 Trip) |
| PTOV2.ST.Str.phsA | Start (59-2 Trip) Phase A |
| PTOV2.ST.Str.dirPhsA | Start (59-2 Trip) Phase A |
| PTOV2.ST.Str.phsB | Start (59-2 Trip) Phase B |
| PTOV2.ST.Str.dirPhsB | Start (59-2 Trip) Phase B |
| PTOV2.ST.Str.phsC | Start (59-2 Trip) Phase C |
| PTOV2.ST.Str.dirPhsC | Start (59-2 Trip) Phase C |

### PTUV1

This section defines logical node data for the logical node PTUV1 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTUV1.ST.Str.general | Start (27-1 Trip) |
| PTUV1.ST.Str.dirGeneral | Start (27-1 Trip) |
| PTUV1.ST.Op.general | Operate (27-1 Trip) |
| PTUV1.ST.Op.phsA | Operate (27-1 Trip) Phase A |
| PTUV1.ST.Op.phsB | Operate (27-1 Trip) Phase B |
| PTUV1.ST.Op.phsC | Operate (27-1 Trip) Phase C |

### PTUV2

This section defines logical node data for the logical node PTUV2 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTUV2.ST.Str.general | Start (27-2 Trip) |
| PTUV2.ST.Str.dirGeneral | Start (27-2 Trip) |
| PTUV2.ST.Op.general | Operate (27-2 Trip) |
| PTUV2.ST.Op.phsA | Operate (27-2 Trip) Phase A |
| PTUV2.ST.Op.phsB | Operate (27-2 Trip) Phase B |
| PTUV2.ST.Op.phsC | Operate (27-2 Trip) Phase C |

### RVTS1

This section defines logical node data for the logical node RVTS1 of the B-PRO logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

Note: RVTS is not defined in IEC61850 and is not in the ICD file.

| Data name | Description |
|---|---|
| RVTS1.ST.Str.general | Start (60 Alarm) |
| RVTS1.ST.Str.dirGeneral | Start (60 Alarm) |
| RVTS1.ST.Str.phsA | Start (60 Alarm) Phase A |
| RVTS1.ST.Str.dirPhsA | Start (60 Alarm) Phase A |
| RVTS1.ST.Str.phsB | Start (60 Alarm) Phase B |
| RVTS1.ST.Str.dirPhsB | Start (60 Alarm) Phase B |
| RVTS1.ST.Str.phsC | Start (60 Alarm) Phase C |
| RVTS1.ST.Str.dirPhsC | Start (60 Alarm) Phase C |

### PTUF1

This section defines logical node data for the logical node PTUF1 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTUF1.ST.Str.general | Start (81 U/F-1 Trip) |
| PTUF1.ST.Str.dirGeneral | Start (81 U/F-1 Trip) |
| PTUF1.ST.Op.general | Operate (81 U/F-1 Trip) |

### PTUF2

This section defines logical node data for the logical node PTUF2 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTUF2.ST.Str.general | Start (81 U/F-2 Trip) |
| PTUF2.ST.Str.dirGeneral | Start (81 U/F-2 Trip) |
| PTUF2.ST.Op.general | Operate (81 U/F-2 Trip) |

### PTOF1

This section defines logical node data for the logical node PTOF1 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOF1.ST.Str.general | Start (81 O/F-1 Trip) |
| PTOF1.ST.Str.dirGeneral | Start (81 O/F-1 Trip) |
| PTOF1.ST.Op.general | Operate (81 O/F-1 Trip) |

### PTOF2

This section defines logical node data for the logical node PTOF2 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOF2.ST.Str.general | Start (81 O/F-2 Trip) |
| PTOF2.ST.Str.dirGeneral | Start (81 O/F-2 Trip) |
| PTOF2.ST.Op.general | Operate (81 O/F-2 Trip) |

### PIOC1

This section defines logical node data for the logical node PIOC1 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC1.ST.Op.general | Operate (Input1: 50LS-1 Trip) |
| PIOC1.ST.Op.phsA | Operate (Input1: 50LS-1 Trip) Phase A |
| PIOC1.ST.Op.phsB | Operate (Input1: 50LS-1 Trip) Phase B |
| PIOC1.ST.Op.phsC | Operate (Input1: 50LS-1 Trip) Phase C |

### PIOC2

This section defines logical node data for the logical node PIOC2 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC2.ST.Op.general | Operate (Input2: 50LS-1 Trip) |
| PIOC2.ST.Op.phsA | Operate (Input2: 50LS-1 Trip) Phase A |
| PIOC2.ST.Op.phsB | Operate (Input2: 50LS-1 Trip) Phase B |
| PIOC2.ST.Op.phsC | Operate (Input2: 50LS-1 Trip) Phase C |

### PIOC3

This section defines logical node data for the logical node PIOC3 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC3.ST.Op.general | Operate (Input3: 50LS-1 Trip) |
| PIOC3.ST.Op.phsA | Operate (Input3: 50LS-1 Trip) Phase A |
| PIOC3.ST.Op.phsB | Operate (Input3: 50LS-1 Trip) Phase B |
| PIOC3.ST.Op.phsC | Operate (Input3: 50LS-1 Trip) Phase C |

### PIOC4

This section defines logical node data for the logical node PIOC4 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC4.ST.Op.general | Operate (Input4: 50LS-1 Trip) |
| PIOC4.ST.Op.phsA | Operate (Input4: 50LS-1 Trip) Phase A |
| PIOC4.ST.Op.phsB | Operate (Input4: 50LS-1 Trip) Phase B |
| PIOC4.ST.Op.phsC | Operate (Input4: 50LS-1 Trip) Phase C |

### PIOC5

This section defines logical node data for the logical node PIOC5 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC5.ST.Op.general | Operate (Input5: 50LS-1 Trip) |
| PIOC5.ST.Op.phsA | Operate (Input5: 50LS-1 Trip) Phase A |
| PIOC5.ST.Op.phsB | Operate (Input5: 50LS-1 Trip) Phase B |
| PIOC5.ST.Op.phsC | Operate (Input5: 50LS-1 Trip) Phase C |

### PIOC6

This section defines logical node data for the logical node PIOC6 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC6.ST.Op.general | Operate (Input6: 50LS-1 Trip) |
| PIOC6.ST.Op.phsA | Operate (Input6: 50LS-1 Trip) Phase A |
| PIOC6.ST.Op.phsB | Operate (Input6: 50LS-1 Trip) Phase B |
| PIOC6.ST.Op.phsC | Operate (Input6: 50LS-1 Trip) Phase C |

### PIOC7

This section defines logical node data for the logical node PIOC7 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC7.ST.Op.general | Operate (Input1: 50LS-2 Trip) |
| PIOC7.ST.Op.phsA | Operate (Input1: 50LS-2 Trip) Phase A |
| PIOC7.ST.Op.phsB | Operate (Input1: 50LS-2 Trip) Phase B |
| PIOC7.ST.Op.phsC | Operate (Input1: 50LS-2 Trip) Phase C |

### PIOC8

This section defines logical node data for the logical node PIOC8 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC8.ST.Op.general | Operate (Input2: 50LS-2 Trip) |
| PIOC8.ST.Op.phsA | Operate (Input2: 50LS-2 Trip) Phase A |
| PIOC8.ST.Op.phsB | Operate (Input2: 50LS-2 Trip) Phase B |
| PIOC8.ST.Op.phsC | Operate (Input2: 50LS-2 Trip) Phase C |

### PIOC9

This section defines logical node data for the logical node PIOC9 of the BPRO-Protection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC9.ST.Op.general | Operate (Input3: 50LS-2 Trip) |
| PIOC9.ST.Op.phsA | Operate (Input3: 50LS-2 Trip) Phase A |
| PIOC9.ST.Op.phsB | Operate (Input3: 50LS-2 Trip) Phase B |
| PIOC9.ST.Op.phsC | Operate (Input3: 50LS-2 Trip) Phase C |

### PIOC10

This section defines logical node data for the logical node PIOC10 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC10.ST.Op.general | Operate (Input4: 50LS-2 Trip) |
| PIOC10.ST.Op.phsA | Operate (Input4: 50LS-2 Trip) Phase A |
| PIOC10.ST.Op.phsB | Operate (Input4: 50LS-2 Trip) Phase B |
| PIOC10.ST.Op.phsC | Operate (Input4: 50LS-2 Trip) Phase C |

### PIOC11

This section defines logical node data for the logical node PIOC11 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC11.ST.Op.general | Operate (Input5: 50LS-2 Trip) |
| PIOC11.ST.Op.phsA | Operate (Input5: 50LS-2 Trip) Phase A |
| PIOC11.ST.Op.phsB | Operate (Input5: 50LS-2 Trip) Phase B |
| PIOC11.ST.Op.phsC | Operate (Input5: 50LS-2 Trip) Phase C |

### PIOC12

This section defines logical node data for the logical node PIOC12 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC12.ST.Op.general | Operate (Input6: 50LS-2 Trip) |
| PIOC12.ST.Op.phsA | Operate (Input6: 50LS-2 Trip) Phase A |
| PIOC12.ST.Op.phsB | Operate (Input6: 50LS-2 Trip) Phase B |
| PIOC12.ST.Op.phsC | Operate (Input6: 50LS-2 Trip) Phase C |

### PIOC13

This section defines logical node data for the logical node PIOC13 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC13.ST.Str.general | Start (Input1: 50/67 Trip) |
| PIOC13.ST.Str.dirGeneral | Start (Input1: 50/67 Trip) |
| PIOC13.ST.Op.general | Operate (Input1: 50/67 Trip) |
| PIOC13.ST.Op.phsA | Operate (Input1: 50/67 Trip) Phase A |
| PIOC13.ST.Op.phsB | Operate (Input1: 50/67 Trip) Phase B |
| PIOC13.ST.Op.phsC | Operate (Input1: 50/67 Trip) Phase C |

### PIOC14

This section defines logical node data for the logical node PIOC14 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC14.ST.Str.general | Start (Input2: 50/67 Trip) |
| PIOC14.ST.Str.dirGeneral | Start (Input2: 50/67 Trip) |
| PIOC14.ST.Op.general | Operate (Input2: 50/67 Trip) |
| PIOC14.ST.Op.phsA | Operate (Input2: 50/67 Trip) Phase A |
| PIOC14.ST.Op.phsB | Operate (Input2: 50/67 Trip) Phase B |
| PIOC14.ST.Op.phsC | Operate (Input2: 50/67 Trip) Phase C |

### PIOC15

This section defines logical node data for the logical node PIOC15 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC15.ST.Str.general | Start (Input3: 50/67 Trip) |
| PIOC15.ST.Str.dirGeneral | Start (Input3: 50/67 Trip) |
| PIOC15.ST.Op.general | Operate (Input3: 50/67 Trip) |
| PIOC15.ST.Op.phsA | Operate (Input3: 50/67 Trip) Phase A |
| PIOC15.ST.Op.phsB | Operate (Input3: 50/67 Trip) Phase B |
| PIOC15.ST.Op.phsC | Operate (Input3: 50/67 Trip) Phase C |

### PIOC16

This section defines logical node data for the logical node PIOC16 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC16.ST.Str.general | Start (Input4: 50/67 Trip) |
| PIOC16.ST.Str.dirGeneral | Start (Input4: 50/67 Trip) |
| PIOC16.ST.Op.general | Operate (Input4: 50/67 Trip) |
| PIOC16.ST.Op.phsA | Operate (Input4: 50/67 Trip) Phase A |
| PIOC16.ST.Op.phsB | Operate (Input4: 50/67 Trip) Phase B |
| PIOC16.ST.Op.phsC | Operate (Input4: 50/67 Trip) Phase C |

### PIOC17

This section defines logical node data for the logical node PIOC17 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC17.ST.Str.general | Start (Input5: 50/67 Trip) |
| PIOC17.ST.Str.dirGeneral | Start (Input5: 50/67 Trip) |
| PIOC17.ST.Op.general | Operate (Input5: 50/67 Trip) |
| PIOC17.ST.Op.phsA | Operate (Input5: 50/67 Trip) Phase A |
| PIOC17.ST.Op.phsB | Operate (Input5: 50/67 Trip) Phase B |
| PIOC17.ST.Op.phsC | Operate (Input5: 50/67 Trip) Phase C |

### PIOC18

This section defines logical node data for the logical node PIOC18 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC18.ST.Str.general | Start (Input6: 50/67 Trip) |
| PIOC18.ST.Str.dirGeneral | Start (Input6: 50/67 Trip) |
| PIOC18.ST.Op.general | Operate (Input6: 50/67 Trip) |
| PIOC18.ST.Op.phsA | Operate (Input6: 50/67 Trip) Phase A |
| PIOC18.ST.Op.phsB | Operate (Input6: 50/67 Trip) Phase B |
| PIOC18.ST.Op.phsC | Operate (Input6: 50/67 Trip) Phase C |

### PIOC19

This section defines logical node data for the logical node PIOC19 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC19.ST.Str.general | Start (Input1: 50N/67 Trip) |
| PIOC19.ST.Str.dirGeneral | Start (Input1: 50N/67 Trip) |
| PIOC19.ST.Op.general | Operate (Input1: 50N/67 Trip) |

### PIOC20

This section defines logical node data for the logical node PIOC20 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC20.ST.Str.general | Start (Input2: 50N/67 Trip) |
| PIOC20.ST.Str.dirGeneral | Start (Input2: 50N/67 Trip) |
| PIOC20.ST.Op.general | Operate (Input2: 50N/67 Trip) |

### PIOC21

This section defines logical node data for the logical node PIOC21 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC21.ST.Str.general | Start (Input3: 50N/67 Trip) |
| PIOC21.ST.Str.dirGeneral | Start (Input3: 50N/67 Trip) |
| PIOC21.ST.Op.general | Operate (Input3: 50N/67 Trip) |

### PIOC22

This section defines logical node data for the logical node PIOC22 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC22.ST.Str.general | Start (Input4: 50N/67 Trip) |
| PIOC22.ST.Str.dirGeneral | Start (Input4: 50N/67 Trip) |
| PIOC22.ST.Op.general | Operate (Input4: 50N/67 Trip) |

### PIOC23

This section defines logical node data for the logical node PIOC23 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC23.ST.Str.general | Start (Input5: 50N/67 Trip) |
| PIOC23.ST.Str.dirGeneral | Start (Input5: 50N/67 Trip) |
| PIOC23.ST.Op.general | Operate (Input5: 50N/67 Trip) |

### PIOC24

This section defines logical node data for the logical node PIOC24 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC24.ST.Str.general | Start (Input6: 50N/67 Trip) |
| PIOC24.ST.Str.dirGeneral | Start (Input6: 50N/67 Trip) |
| PIOC24.ST.Op.general | Operate (Input6: 50N/67 Trip) |

### PIOC25

This section defines logical node data for the logical node PIOC25 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC25.ST.Str.general | Start (Input1: 46-50/67 Trip) |
| PIOC25.ST.Str.dirGeneral | Start (Input1: 46-50/67 Trip) |
| PIOC25.ST.Op.general | Operate (Input1: 46-50/67 Trip) |

### PIOC26

This section defines logical node data for the logical node PIOC26 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC26.ST.Str.general | Start (Input2: 46-50/67 Trip) |
| PIOC26.ST.Str.dirGeneral | Start (Input2: 46-50/67 Trip) |
| PIOC26.ST.Op.general | Operate (Input2: 46-50/67 Trip) |

### PIOC27

This section defines logical node data for the logical node PIOC27 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC27.ST.Str.general | Start (Input3: 46-50/67 Trip) |
| PIOC27.ST.Str.dirGeneral | Start (Input3: 46-50/67 Trip) |
| PIOC27.ST.Op.general | Operate (Input3: 46-50/67 Trip) |

### PIOC28

This section defines logical node data for the logical node PIOC28 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC28.ST.Str.general | Start (Input4: 46-50/67 Trip) |
| PIOC28.ST.Str.dirGeneral | Start (Input4: 46-50/67 Trip) |
| PIOC28.ST.Op.general | Operate (Input4: 46-50/67 Trip) |

### PIOC29

This section defines logical node data for the logical node PIOC29 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC29.ST.Str.general | Start (Input5: 46-50/67 Trip) |
| PIOC29.ST.Str.dirGeneral | Start (Input5: 46-50/67 Trip) |
| PIOC29.ST.Op.general | Operate (Input5: 46-50/67 Trip) |

### PIOC30

This section defines logical node data for the logical node PIOC30 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PIOC30.ST.Str.general | Start (Input6: 46-50/67 Trip) |
| PIOC30.ST.Str.dirGeneral | Start (Input6: 46-50/67 Trip) |
| PIOC30.ST.Op.general | Operate (Input6: 46-50/67 Trip) |

### PTOC1

This section defines logical node data for the logical node PTOC1 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC1.ST.Str.general | Start (Input1: 51/67 Alarm) |
| PTOC1.ST.Str.dirGeneral | Start (Input1: 51/67 Alarm) |
| PTOC1.ST.Op.general | Operate (Input1: 51/67 Trip) |
| PTOC1.ST.Op.phsA | Operate (Input1: 51/67 Trip) Phase A |
| PTOC1.ST.Op.phsB | Operate (Input1: 51/67 Trip) Phase B |
| PTOC1.ST.Op.phsC | Operate (Input1: 51/67 Trip) Phase C |

### PTOC2

This section defines logical node data for the logical node PTOC2 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC2.ST.Str.general | Start (Input2: 51/67 Alarm) |
| PTOC2.ST.Str.dirGeneral | Start (Input2: 51/67 Alarm) |
| PTOC2.ST.Op.general | Operate (Input2: 51/67 Trip) |
| PTOC2.ST.Op.phsA | Operate (Input2: 51/67 Trip) Phase A |
| PTOC2.ST.Op.phsB | Operate (Input2: 51/67 Trip) Phase B |
| PTOC2.ST.Op.phsC | Operate (Input2: 51/67 Trip) Phase C |

### PTOC3

This section defines logical node data for the logical node PTOC3 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC3.ST.Str.general | Start (Input3: 51/67 Alarm) |
| PTOC3.ST.Str.dirGeneral | Start (Input3: 51/67 Alarm) |
| PTOC3.ST.Op.general | Operate (Input3: 51/67 Trip) |
| PTOC3.ST.Op.phsA | Operate (Input3: 51/67 Trip) Phase A |
| PTOC3.ST.Op.phsB | Operate (Input3: 51/67 Trip) Phase B |
| PTOC3.ST.Op.phsC | Operate (Input3: 51/67 Trip) Phase C |

### PTOC4

This section defines logical node data for the logical node PTOC4 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC4.ST.Str.general | Start (Input4: 51/67 Alarm) |
| PTOC4.ST.Str.dirGeneral | Start (Input4: 51/67 Alarm) |
| PTOC4.ST.Op.general | Operate (Input4: 51/67 Trip) |
| PTOC4.ST.Op.phsA | Operate (Input4: 51/67 Trip) Phase A |
| PTOC4.ST.Op.phsB | Operate (Input4: 51/67 Trip) Phase B |
| PTOC4.ST.Op.phsC | Operate (Input4: 51/67 Trip) Phase C |

### PTOC5

This section defines logical node data for the logical node PTOC5 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC5.ST.Str.general | Start (Input5: 51/67 Alarm) |
| PTOC5.ST.Str.dirGeneral | Start (Input5: 51/67 Alarm) |
| PTOC5.ST.Op.general | Operate (Input5: 51/67 Trip) |
| PTOC5.ST.Op.phsA | Operate (Input5: 51/67 Trip) Phase A |
| PTOC5.ST.Op.phsB | Operate (Input5: 51/67 Trip) Phase B |
| PTOC5.ST.Op.phsC | Operate (Input5: 51/67 Trip) Phase C |

### PTOC6

This section defines logical node data for the logical node PTOC6 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC6.ST.Str.general | Start (Input6: 51/67 Alarm) |
| PTOC6.ST.Str.dirGeneral | Start (Input6: 51/67 Alarm) |
| PTOC6.ST.Op.general | Operate (Input6: 51/67 Trip) |
| PTOC6.ST.Op.phsA | Operate (Input6: 51/67 Trip) Phase A |
| PTOC6.ST.Op.phsB | Operate (Input6: 51/67 Trip) Phase B |
| PTOC6.ST.Op.phsC | Operate (Input6: 51/67 Trip) Phase C |

### PTOC7

This section defines logical node data for the logical node PTOC7 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC7.ST.Str.general | Start (Input1: 51N/67 Alarm) |
| PTOC7.ST.Str.dirGeneral | Start (Input1: 51N/67 Alarm) |
| PTOC7.ST.Op.general | Operate (Input1: 51N/67 Trip) |

### PTOC8

This section defines logical node data for the logical node PTOC8 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC8.ST.Str.general | Start (Input2: 51N/67 Alarm) |
| PTOC8.ST.Str.dirGeneral | Start (Input2: 51N/67 Alarm) |
| PTOC8.ST.Op.general | Operate (Input2: 51N/67 Trip) |

### PTOC9

This section defines logical node data for the logical node PTOC9 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC9.ST.Str.general | Start (Input3: 51N/67 Alarm) |
| PTOC9.ST.Str.dirGeneral | Start (Input3: 51N/67 Alarm) |
| PTOC9.ST.Op.general | Operate (Input3: 51N/67 Trip) |

### PTOC10

This section defines logical node data for the logical node PTOC10 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC10.ST.Str.general | Start (Input4: 51N/67 Alarm) |
| PTOC10.ST.Str.dirGeneral | Start (Input4: 51N/67 Alarm) |
| PTOC10.ST.Op.general | Operate (Input4: 51N/67 Trip) |

### PTOC11

This section defines logical node data for the logical node PTOC7 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC11.ST.Str.general | Start (Input5: 51N/67 Alarm) |
| PTOC11.ST.Str.dirGeneral | Start (Input5: 51N/67 Alarm) |
| PTOC11.ST.Op.general | Operate (Input5: 51N/67 Trip) |

### PTOC12

This section defines logical node data for the logical node PTOC12 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC12.ST.Str.general | Start (Input6: 51N/67 Alarm) |
| PTOC12.ST.Str.dirGeneral | Start (Input6: 51N/67 Alarm) |
| PTOC12.ST.Op.general | Operate (Input6: 51N/67 Trip) |

### PTOC13

This section defines logical node data for the logical node PTOC13 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC13.ST.Str.general | Start (Input1: 46-51/67 Alarm) |
| PTOC13.ST.Str.dirGeneral | Start (Input1: 46-51/67 Alarm) |
| PTOC13.ST.Op.general | Operate (Input1: 46-51/67 Trip) |

**PTOC14**

This section defines logical node data for the logical node PTOC14 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC14.ST.Str.general | Start (Input2: 46-51/67 Alarm) |
| PTOC14.ST.Str.dirGeneral | Start (Input2: 46-51/67 Alarm) |
| PTOC14.ST.Op.general | Operate (Input2: 46-51/67 Trip) |

**PTOC15**

This section defines logical node data for the logical node PTOC15 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC15.ST.Str.general | Start (Input3: 46-51/67 Alarm) |
| PTOC15.ST.Str.dirGeneral | Start (Input3: 46-51/67 Alarm) |
| PTOC15.ST.Op.general | Operate (Input3: 46-51/67 Trip) |

### PTOC16

This section defines logical node data for the logical node PTOC16 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC16.ST.Str.general | Start (Input4: 46-51/67 Alarm) |
| PTOC16.ST.Str.dirGeneral | Start (Input4: 46-51/67 Alarm) |
| PTOC16.ST.Op.general | Operate (Input4: 46-51/67 Trip) |

### PTOC17

This section defines logical node data for the logical node PTOC17 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC17.ST.Str.general | Start (Input5: 46-51/67 Alarm) |
| PTOC17.ST.Str.dirGeneral | Start (Input5: 46-51/67 Alarm) |
| PTOC17.ST.Op.general | Operate (Input5: 46-51/67 Trip) |

### PTOC18

This section defines logical node data for the logical node PTOC18 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| PTOC18.ST.Str.general | Start (Input6: 46-51/67 Alarm) |
| PTOC18.ST.Str.dirGeneral | Start (Input6: 46-51/67 Alarm) |
| PTOC18.ST.Op.general | Operate (Input6: 46-51/67 Trip) |

### RBRF1

This section defines logical node data for the logical node RBRF1 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF1.ST.OpEx.general | Operate (Input1: 50BF-1 Trip) |

### RBRF2

This section defines logical node data for the logical node RBRF2 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF2.ST.OpEx.general | Operate (Input2: 50BF-1 Trip) |

### RBRF3

This section defines logical node data for the logical node RBRF3 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF3.ST.OpEx.general | Operate (Input3: 50BF-1 Trip) |

### RBRF4

This section defines logical node data for the logical node RBRF4 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF4.ST.OpEx.general | Operate (Input4: 50BF-1 Trip) |

### RBRF5

This section defines logical node data for the logical node RBRF5 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF5.ST.OpEx.general | Operate (Input5: 50BF-1 Trip) |

### RBRF6

This section defines logical node data for the logical node RBRF6 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF6.ST.OpEx.general | Operate (Input6: 50BF-1 Trip) |

### RBRF7

This section defines logical node data for the logical node RBRF7 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF7.ST.OpEx.general | Operate (Input1: 50BF-2 Trip) |

### RBRF8

This section defines logical node data for the logical node RBRF8 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF8.ST.OpEx.general | Operate (Input2: 50BF-2 Trip) |

### RBRF9

This section defines logical node data for the logical node RBRF9 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF9.ST.OpEx.general | Operate (Input3: 50BF-2 Trip) |

### RBRF10

This section defines logical node data for the logical node RBRF20 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF20.ST.OpEx.general | Operate (Input4: 50BF-2 Trip) |

### RBRF11

This section defines logical node data for the logical node RBRF11 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF11.ST.OpEx.general | Operate (Input5: 50BF-2 Trip) |

### RBRF12

This section defines logical node data for the logical node RBRF12 of the BPROProtection logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| RBRF12.ST.OpEx.general | Operate (Input6: 50BF-2 Trip) |

### GGIO1

This section defines logical node data for the logical node GGIO1 of the BPROSystem logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| GGIO1.ST.Ind1.stVal | General Indication (binary input) – External Input 1 |
| GGIO1.ST.Ind2.stVal | General Indication (binary input) – External Input 2 |
| GGIO1.ST.Ind3.stVal | General Indication (binary input) – External Input 3 |
| GGIO1.ST.Ind4.stVal | General Indication (binary input) – External Input 4 |
| GGIO1.ST.Ind5.stVal | General Indication (binary input) – External Input 5 |
| GGIO1.ST.Ind6.stVal | General Indication (binary input) – External Input 6 |
| GGIO1.ST.Ind7.stVal | General Indication (binary input) – External Input 7 |
| GGIO1.ST.Ind8.stVal | General Indication (binary input) – External Input 8 |
| GGIO1.ST.Ind9.stVal | General Indication (binary input) – External Input 9 |

| | |
|---|---|
| GGIO1.ST.Ind10.stVal to GGIO1.ST.Ind64.stVal | General Indication (binary input) – Reserved (future use) |

**GGIO2**

This section defines logical node data for the logical node GGIO2 of the BPROSystem logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| GGIO2.ST.Ind1.stVal | General Indication (binary input) – Output Contact 1 |
| GGIO2.ST.Ind2.stVal | General Indication (binary input) – Output Contact 2 |
| GGIO2.ST.Ind3.stVal | General Indication (binary input) – Output Contact 3 |
| GGIO2.ST.Ind4.stVal | General Indication (binary input) – Output Contact 4 |
| GGIO2.ST.Ind5.stVal | General Indication (binary input) – Output Contact 5 |
| GGIO2.ST.Ind6.stVal | General Indication (binary input) – Output Contact 6 |
| GGIO2.ST.Ind7.stVal | General Indication (binary input) – Output Contact 7 |
| GGIO2.ST.Ind8.stVal | General Indication (binary input) – Output Contact 8 |
| GGIO2.ST.Ind9.stVal | General Indication (binary input) – Output Contact 9 |
| GGIO2.ST.Ind10.stVal | General Indication (binary input) – Output Contact 10 |
| GGIO2.ST.Ind11.stVal | General Indication (binary input) – Output Contact 11 |
| GGIO2.ST.Ind12.stVal | General Indication (binary input) – Output Contact 12 |
| GGIO2.ST.Ind13.stVal | General Indication (binary input) – Output Contact 13 |
| GGIO2.ST.Ind14.stVal | General Indication (binary input) – Output Contact 14 |
| GGIO2.ST.Ind15.stVal to GGIO2.ST.Ind64.stVal | General Indication (binary input) – Reserved (future use) |

### GGIO3

This section defines logical node data for the logical node GGIO3 of the BPROSystem logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| GGIO3.ST.Ind1.stVal | General Indication (binary input) – ProLogic 1 |
| GGIO3.ST.Ind2.stVal | General Indication (binary input) – ProLogic 2 |
| GGIO3.ST.Ind3.stVal | General Indication (binary input) – ProLogic 3 |
| GGIO3.ST.Ind4.stVal | General Indication (binary input) – ProLogic 4 |
| GGIO3.ST.Ind5.stVal | General Indication (binary input) – ProLogic 5 |
| GGIO3.ST.Ind6.stVal | General Indication (binary input) – ProLogic 6 |
| GGIO3.ST.Ind7.stVal | General Indication (binary input) – ProLogic 7 |
| GGIO3.ST.Ind8.stVal | General Indication (binary input) – ProLogic 8 |
| GGIO3.ST.Ind9.stVal | General Indication (binary input) – ProLogic 9 |
| GGIO3.ST.Ind10.stVal | General Indication (binary input) – ProLogic 10 |
| GGIO3.ST.Ind11.stVal | General Indication (binary input) – ProLogic 11 |
| GGIO3.ST.Ind12.stVal | General Indication (binary input) – ProLogic 12 |
| GGIO3.ST.Ind13.stVal | General Indication (binary input) – ProLogic 13 |
| GGIO3.ST.Ind14.stVal | General Indication (binary input) – ProLogic 14 |
| GGIO3.ST.Ind15.stVal | General Indication (binary input) – ProLogic 15 |
| GGIO3.ST.Ind16.stVal to GGIO3.ST.Ind64.stVal | General Indication (binary input) – Reserved (future use) |

### GGIO1

This section defines logical node data for the logical node GGIO1 of the BPROVirtualElements logical device which is used for GOOSE Publication purpose.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

| Data name | Description |
|---|---|
| GGIO1.ST.Ind1.stVal | General Indication (binary input) – Virtual Input 1 |
| GGIO1.ST.Ind2.stVal | General Indication (binary input) – Virtual Input 2 |
| GGIO1.ST.Ind3.stVal | General Indication (binary input) – Virtual Input 3 |
| GGIO1.ST.Ind4.stVal | General Indication (binary input) – Virtual Input 4 |
| GGIO1.ST.Ind5.stVal | General Indication (binary input) – Virtual Input 5 |
| GGIO1.ST.Ind6.stVal | General Indication (binary input) – Virtual Input 6 |
| GGIO1.ST.Ind7.stVal | General Indication (binary input) – Virtual Input 7 |
| GGIO1.ST.Ind8.stVal | General Indication (binary input) – Virtual Input 8 |
| GGIO1.ST.Ind9.stVal | General Indication (binary input) – Virtual Input 9 |
| GGIO1.ST.Ind10.stVal | General Indication (binary input) – Virtual Input 10 |
| GGIO1.ST.Ind11.stVal | General Indication (binary input) – Virtual Input 11 |
| GGIO1.ST.Ind12.stVal | General Indication (binary input) – Virtual Input 12 |
| GGIO1.ST.Ind13.stVal | General Indication (binary input) – Virtual Input 13 |
| GGIO1.ST.Ind14.stVal | General Indication (binary input) – Virtual Input 14 |
| GGIO1.ST.Ind15.stVal | General Indication (binary input) – Virtual Input 15 |
| GGIO1.ST.Ind16.stVal | General Indication (binary input) – Virtual Input 16 |
| GGIO1.ST.Ind17.stVal | General Indication (binary input) – Virtual Input 17 |

| | |
|---|---|
| GGIO1.ST.Ind18.stVal | General Indication (binary input) – Virtual Input 18 |
| GGIO1.ST.Ind19.stVal | General Indication (binary input) – Virtual Input 19 |
| GGIO1.ST.Ind20.stVal | General Indication (binary input) – Virtual Input 20 |
| GGIO1.ST.Ind21.stVal | General Indication (binary input) – Virtual Input 21 |
| GGIO1.ST.Ind22.stVal | General Indication (binary input) – Virtual Input 22 |
| GGIO1.ST.Ind23.stVal | General Indication (binary input) – Virtual Input 23 |
| GGIO1.ST.Ind24.stVal | General Indication (binary input) – Virtual Input 24 |
| GGIO1.ST.Ind25.stVal | General Indication (binary input) – Virtual Input 25 |
| GGIO1.ST.Ind26.stVal | General Indication (binary input) – Virtual Input 26 |
| GGIO1.ST.Ind27.stVal | General Indication (binary input) – Virtual Input 27 |
| GGIO1.ST.Ind28.stVal | General Indication (binary input) – Virtual Input 28 |
| GGIO1.ST.Ind29.stVal | General Indication (binary input) – Virtual Input 29 |
| GGIO1.ST.Ind30.stVal | General Indication (binary input) – Virtual Input 30 |

### GGIO2

This section defines logical node data for the logical node GGIO2 of the BPROVirtualElements logical device which is used for GOOSE Subscription-mapping purpose.

Notes:

1. Common Logical Node information is not shown here. Only the data that are provided from the IEC 61850 sub-system to the B-PRO application are listed here.
2. Supported Virtual Input control commands are:

   1 – Latch On

   0 – Latch Off

Any other values written to the "`GGIO2.ST.Ind(1-30).stVal`" will be ignored.

| Data name | Description |
|---|---|
| GGIO2.ST. Ind1.stVal | General Indication (binary input) – Virtual Input 1 |
| GGIO2.ST. Ind2.stVal | General Indication (binary input) – Virtual Input 2 |
| GGIO2.ST. Ind3.stVal | General Indication (binary input) – Virtual Input 3 |
| GGIO2.ST. Ind4.stVal | General Indication (binary input) – Virtual Input 4 |
| GGIO2.ST. Ind5.stVal | General Indication (binary input) – Virtual Input 5 |
| GGIO2.ST. Ind6.stVal | General Indication (binary input) – Virtual Input 6 |
| GGIO2.ST. Ind7.stVal | General Indication (binary input) – Virtual Input 7 |
| GGIO2.ST. Ind8.stVal | General Indication (binary input) – Virtual Input 8 |
| GGIO2.ST. Ind9.stVal | General Indication (binary input) – Virtual Input 9 |
| GGIO2.ST. Ind10.stVal | General Indication (binary input) – Virtual Input 10 |
| GGIO2.ST. Ind11.stVal | General Indication (binary input) – Virtual Input 11 |
| GGIO2.ST. Ind12.stVal | General Indication (binary input) – Virtual Input 12 |
| GGIO2.ST. Ind13.stVal | General Indication (binary input) – Virtual Input 13 |
| GGIO2.ST. Ind14.stVal | General Indication (binary input) – Virtual Input 14 |

| | |
|---|---|
| GGIO2.ST. Ind15.stVal | General Indication (binary input) – Virtual Input 15 |
| GGIO2.ST. Ind16.stVal | General Indication (binary input) – Virtual Input 16 |
| GGIO2.ST. Ind17.stVal | General Indication (binary input) – Virtual Input 17 |
| GGIO2.ST. Ind18.stVal | General Indication (binary input) – Virtual Input 18 |
| GGIO2.ST. Ind19.stVal | General Indication (binary input) – Virtual Input 19 |
| GGIO2.ST. Ind20.stVal | General Indication (binary input) – Virtual Input 20 |
| GGIO2.ST. Ind21.stVal | General Indication (binary input) – Virtual Input 21 |
| GGIO2.ST. Ind22.stVal | General Indication (binary input) – Virtual Input 22 |
| GGIO2.ST. Ind23.stVal | General Indication (binary input) – Virtual Input 23 |
| GGIO2.ST. Ind24.stVal | General Indication (binary input) – Virtual Input 24 |
| GGIO2.ST. Ind25.stVal | General Indication (binary input) – Virtual Input 25 |
| GGIO2.ST. Ind26.stVal | General Indication (binary input) – Virtual Input 26 |
| GGIO2.ST. Ind27.stVal | General Indication (binary input) – Virtual Input 27 |
| GGIO2.ST. Ind28.stVal | General Indication (binary input) – Virtual Input 28 |
| GGIO2.ST. Ind29.stVal | General Indication (binary input) – Virtual Input 29 |
| GGIO2.ST. Ind30.stVal | General Indication (binary input) – Virtual Input 30 |

### GGIO3

This section defines logical node data for the logical node GGIO3 of the BPROVirtualElements logical device.

Note:

Common Logical Node information is not shown here. Only the data that are provided from the B-PRO application to the IEC 61850 sub-system are listed here.

This section is not used in the current release and reserved for the future implementation purpose.

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